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ADVANCED MODULAR LIGHTERAGE/PLATFORM TECHNOLOGY DEVELOPMENT, PHASE II - FINAL REPORT

Prepared for:

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ESC31
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13. ABSTRACT *(Maximum 200 words)*

This report documents a conceptual design effort for the Amphibious Cargo Beaching (ACB) Lighter, a modular barge system which is being developed to replace the Navy Lighter (NL) pontoon causeway system. The ACB Lighter will be rapidly deployed from an auxiliary crane ship and be assembled and operated in sea conditions through sea state three to support Joint Logistics Over the Shore (JLOTS) operations. During a Phase I effort, which was documented in NFESC CR 96.013 (ADA318036), design procedures were established, requirements for module stowage, stacking and handling were identified, and fittings for handling, stacking, cargo tie-down, and mooring were selected. The Phase I effort culminated in the preliminary structural design of 24-ft wide monocoque ACB Lighter modules. The objectives of this Phase II study were: (1) develop structural design guidelines which can be used to design a lightweight module structure; (2) account for structure required to mount flexible and rigid connector assemblies and its impact on hull weight; (3) revise preliminary design to reflect modified design criteria; and (4) if final design resulted in a module which exceeded the 30-long ton design goal, assess impact on handling, stacking and transporting.

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Naval Facilities Engineering Service Center (NFESC) and M. Rosenblatt & Son, Inc. (MR&S) would like to express their thanks and appreciation to Peck & Hale Inc. (P&H) of West Sayville, NY for providing drawings of standard container fittings, and cargo tie-down fittings depicted in Figures 3-8, 3-9, 3-11, 3-12 and 3-13 of this report and for granting permission to NFESC & MR&S for the reproduction of the above drawings in accordance with the conditions defined in P&H letter to MR&S (dated October 24, 1995).

EXECUTIVE SUMMARY

This report documents the results of the second phase effort performed by M. Rosenblatt & Son, Inc. (MR&S) under NFESC Contract N47408-95-C-0211. The report addresses several critical issues germane to the Advanced Modular Lighterage/Platform Development Program. The key building block of this program is the modular Amphibious Cargo Beaching (ACB) Lighter, being developed by NFESC Code ESC31.

The new ACB Lighter is to overcome the many limitations that the existing Navy Lighter (NL) and the Army's Modular Causeway System (MCS) have in cargo capacity, freeboard, transportability and operating capability in higher than Sea State 2 weather condition which is the present limit for operation. In addition, the existing Navy lighterage must be transported fully assembled on the top side of its transport ships. Only a limited number of lighters can be carried aboard a few suitable classes of ships.

At the present time, the U.S. Navy and Army are procuring a number of modern Roll-On/Roll-Off type Sealift ships to enhance its capability to transport military cargo. At the same time, at the final link of the Sealift chain, when cargo is transported from ship to shore, the existing deficient lighterage systems are used to conduct the crucial Logistics Over The Shore (LOTS) operations.

The new ACB Lighterage System is based on the development of standard modules that will be easy to transport and assemble on site. The 24 ft wide by 120 ft long by 8 ft deep ACB Lighter is assembled from three (3) 40 ft long modules which are the constant depth center module and the raked bow and the raked stern modules. The 40 ft long modules would be capable of being stacked and transported in standard container ship cell guides and in the container holds of special Navy ships such as the Auxiliary Crane Ship (T-ACS). The in hold container guide interface and the stacking of the ACB Lighter Modules is similar to that of the SEA SHED tween deck modules.

As a key Phase I design objective for the handling, transportation and stacking of the modules, the maximum gross handling weight (structure, attached fittings and connector assemblies) for each module was set at 30 LT (67,200 lbs) the same as the maximum gross weight of a standard 40 ft ISO container.

Despite considerable progress made in developing the preliminary structural design criteria for the ACB lighter modules, this first phase development effort could not achieve the 67,200 lbs maximum allowable weight limit for the lighter module(s). As shown in Tables 3-7.1 and 3-7.2 the total estimated module weights are 87,975 and 75,031 lbs for the center and raked ACB lighter modules respectively. Therefore, the estimated center and raked module weights exceed the 67,200 lbs allowable weight limit by 20,775 lbs and 7,831 lbs respectively.

Nevertheless, the objective of this second phase design development study is to find feasible ways to design a lightweight module structure of steel construction which is durable and can be reliably operated for the intended service in a Sea State 3 environment while conducting Logistics Over The Shore (LOTS) operations.

Under Phase II of this contract MR&S has been tasked by NFESC Code ECS31 to address the following critical issues:

- Final development of the ACB Lighter structural design criteria started under Phase I of this contract. The intent of this effort is to develop structural design guidelines which can be used to design a lightweight module/lighter structure of steel construction for the specified service and loads.

- Module handling weight assessment based on best results achieved by using Phase II developed design criteria including hull integration and weight impact study for the NFESC developed Rigid Connector Assembly.

- ACB Lighter module intermodal requirements and transportation study.

- Handling study including impact assessment for handling, stacking and transporting heavier than 30 LT modules to evaluate operational impact of excess weight modules in case the 30 LT handling weight design objective can not be achieved.

This Phase II study concentrated on the final development and evaluation of the various applicable options for efficient and lightweight structural design, outfitting, handling, transportation and stacking of the ACB lighter modules.

The main results of this Phase II effort can be summarized as follows:

1. Structural Design Criteria

   This finalized structural design criteria is presented in Section 3.2 of this report. The design criteria is a combination of selected ABS River Barge Rules, Reference (4); commercial RO-RO ship deck design practices in accordance with procedures defined in Reference (2), “Design for Deck Structures Under Wheel Loads” by R.I. Jackson & P.A. Frieze and utilizing some U.S. Navy rules for allowable stresses, in accordance with 0900-L8-097-4010 “Structural Design Manual for Naval Surface Ships” 1976, Reference (3). The U.S. Navy rules for allowable bending stresses were adapted in combination with applicable ABS rules to allow about 20% higher bending stresses in selected hull structural members.

   MR&S believes that the adaptation of the developed structural design criteria by NFESC would allow the design of the lightest possible hull and deck structure for the ACB Lighter modules which could reliably be used for the intended loadings and service in a Sea State 3 environment.

2. Estimated Hull Scantlings and Weights

   In order to verify the magnitude of the attainable hull structure weight savings, relative to the Phase I Study results, MR&S performed a preliminary scantling design and weight estimate of the ACB Lighter hull structure. The preliminary design was performed in accordance with the recommended structural design criteria presented in Section 3.2 of this study.

The calculated scantling sizes for the center and raked modules are shown in Figures 3-1 and 3-2 respectively.

The comparison study made between the Phase I and Phase II estimated scantling weights of the center or raked module structures is presented below. The Phase I estimated scantling weights are taken from Tables 3-5.8 and 3-5.9 of Reference (1), the comparable Phase II estimated scantling weights are listed in Tables 3-1 and 3-2 of this report.

Comparison of Phase I and Phase II estimated scanting weights:	Center Module (lbs)	Raked Module (lbs)
a. Estimated Phase I Basic Scantling Wt *(*)*:	58,411	54,811
b. Estimated Phase II Basic Scantling Wt *(*)*:	53,544	50,245
c. Estimated Phase II Basic Scantling Wt Inc/(Dec), (a-b):	(4,867)	(4,566)
d. Estimated Phase II Recess & Foundation Wt:	11,430	8,088
e. Total Estimated Phase II Scantling Wt (b+d):	64,974	58,333
f. Total Estimated Phase II Scantling Wt Inc/(Dec), (e-a):	6,563	3,522

(*) Does not include the weight impact at the connector recesses and related foundations.

The results indicate that the comparable basic scantling weight of the center and raked module structures were reduced in the Phase II preliminary design by 4,867 lbs and 4,566 lbs, respectively.

The reductions in scantling weights were made possible by the revised design criteria in Section 3.2.3.2. This criteria specifies a 20% higher allowable bending stress than the Phase I allowable bending stress. The results met the Phase II objectives for basic structural weight reduction. However, in this study MR&S also made a realistic assessment of the structural weight impact for the connector recesses and foundations in way of the rigid connector assembly installations. Due to the large size of the recesses (see Figures 3-3 and 3-4) and the large connector imposed loadings on the structure the impact on the structural weight was found to be considerable. MR&S estimated the net structural weight increases caused by the recesses and the built-in connector foundations. The estimated weights are listed in Tables 3-1 and 3-2 as 11,430 lbs for the six (6) center module recesses and 8,088 lbs for the four (4) raked module recesses. These additional structural weights raise the total estimated scantling weights of the center and raked module structures to 64,974 lbs and 58,333 lbs respectively. Thus the connector recess related structural weight increases, which were not calculated in the Phase I Study, have increased the Phase II estimated total scantling weights of the center and raked module structures by 6,553 lbs and 3,522 lbs over the corresponding Phase I weights.

3. Handling

In order to maximize the intermodal features of the ACB Lighter Modules, from the standpoint of handling and transportation, the original design objective for module handling weight has been set at 67,200 lbs, (30 LT) maximum. This handling weight limit is the same as the maximum allowable gross handling weight of a standard 40 foot ISO cargo container. The intent of the 30 LT handling weight limit for the lighter modules was to ensure that the handling of the modules would be possible with any existing standard 40 foot container spreader, standard container cranes and container trailers or chassis which are commonly used in containership terminals.

The results of this study indicate that with the present weight budget for the NFESC developed modular connector assemblies and the additional structural weight increase due to the large recesses required for the connector assemblies in the hull structure and related foundations in way of the connector installations the 30 LT module handling weight design objective can not be achieved. MR&S estimated in this study that the actual handling weight for the center and raked modules of the ACB Lighter would be 99,744 lbs or 44.35 LT and 83,659 lbs or 37.75 LT as shown in Tables 3-.4.1 and 3-4.2, respectively. These estimated handling weights are about 14.35 LT and 7.35 LT in excess of the design objective. Therefore the handling of the ACB Lighter modules in commercial container terminals using standard 30 LT capacity container handling gear would not be permissible.

However, some of the new and updated commercial container handling facilities, in addition to the standard 30 LT capacity handling equipment, may also have high capacity container cranes and container spreaders with up to 50 LT load capacity under the spreader. One example of this high capacity equipment is the ASX7 type universal container spreader manufactured by Bromma Inc. of Roxboro, N.C. This particular spreader, suitable for handling 20 Ft, 40 Ft and 45 Ft long standard ISO cargo containers, can also handle up to 50 LT concentric loads and up to 40 LT loads when the load center has a 10% offset relative to the center of the four pick-up points (twist locks), see Reference (10). The spreader is equipped with standard ISO size twist locks for handling. It should be noted that the standard topside ISO container corner fittings and twist locks have sufficient margin in their safety factors that allow the safe handling of the higher loads, see Reference (11).

Container crane manufacturers such as Paceco Corp. of San Mateo CA, manufacture high capacity container cranes which can utilize the 50 LT capacity spreaders. The estimated 44.35 LT and 37.75 LT respective handling weights for the ACB Lighter center and raked modules are within the stated capabilities of the high capacity handling equipment.

Therefore, commercial container terminals and military cargo terminals equipped with this high capacity handling gear could handle (load/offload) the ACB Lighter modules. However, it can reasonably be assumed that the stockpiling and portside handling of the ACB Lighter modules will not take place in commercial container terminals but rather in designated cargo terminals of the Military Sealift Command (MSC).

While the excess handling weight condition of the modules tend to pose some problems in the handling and transportation of the ACB Lighter modules, MR&S believes that with proper planning and equipment selection those issues can be resolved and thus the viability of the ACB Lighter program can be maintained without any real compromise. Nevertheless, the excess weight problem could also be diminished in the future by implementing changes in the rigid connector assembly design and the way the connectors are integrated into the lighter hull.

4. Recommendations

MR&S recommends that in order to eliminate or reduce the present excess handling weight of the lighter modules and to possibly lower potential construction and maintenance costs the following issues be considered by NFESC for implementation in the future phases of the ACB Lighter program.

- Retain the best features such as the prealignment pin and bridle system of the present rigid connector design.

- Consider alternate solutions to the present bulky, heavy and difficult to integrate modular connector assembly. The present modular design is structurally intrusive and greatly increases the structural weight of the lighter modules.

- Consider increasing the module depth to 8'-6", the additional 6 inches of hull depth would allow to place the connector pins further apart in the vertical direction. The present 4'-0" centerline to centerline distance results in very high concentrated connector loads. In addition, locating the connector pins closer to the top and bottom sides of the module should also be considered for increased center distance. However, it should be noted that while the increased module depth and connection pin centerline distance would result in decrease in the connector loads for the same bending moment but would increase construction cost and cube required for transportation.

- While the presently selected raised cargo tie-down fittings are the lightest and least expensive to install the potential negative safety aspect of the raised installation for personnel on deck and for vehicle traffic and cargo (container) spotting should be reviewed for acceptability.

- Consider a new survey of the candidate container ships, commercial and Military Sealift Ships, to identify suitable cargo holds for the transportation of the 8 ft deep by 24 ft wide by 40 ft long ACB Lighter modules. Hold locations, container guide configurations, stack heights and current container support capacities should be identified and recorded. This information would facilitate future planning and ship utilization in case of need. Past surveys of similar scope have been performed for the SEA SHED project but the results are obsolete, many ships in the previous survey are no longer in service.

1.0 INTRODUCTION

1.1 Objectives

The primary objectives of this Phase II Preliminary Study are:

(a) Final development of the ACB Lighter structural design criteria started under Phase I of this contract. The intent of this effort is to develop structural design guidelines which can be used to design a lightweight module/lighter structure of steel construction for the specified service and loads.

(b) NFESC Rigid Connector Assembly hull integration and weight impact study.

(c) Final selection and arrangement including weight impact study of ACB Lighter service suitable hull mounted fittings for stacking handling, cargo tie down and mooring.

(d) Module handling weight assessment based on best results achieved by using Phase II developed design criteria.

(e) ACB Lighter module intermodal requirements and transportation study.

(f) Handling study including impact assessment for handling, stacking and transporting heavier than 30 LT modules.(*)

(*) *Operational impact of excess weight modules must be assessed in case the 30 LT handling weight design objective can not be achieved.*

1.2 Scope

This second phase report documents the findings of the following tasks performed under NFESC Contract N47408-95-C-0211 by M. Rosenblatt & Son, Inc. (MR&S). The tasks performed in this study for NFESC Code ESC31 are part of the ongoing engineering effort of the Advanced Modular Lighterage/Platform Technology Development Program.

Section 1.0, of this report presents a brief overview of the objectives of the Amphibious Cargo Beaching (ACB) Lighter Development Program and this study. Section 2.0, provides a brief overview of the ACB Lighter Concept. Section 3.0 addresses all of the major issues dealt with in Phase I of this contract and are further developed in this Phase II Study for the design development of the ACB Lighter scantlings, hull systems and fittings. Section 4.0, is a review of intermodal requirements for the ACB Lighter module. Section 5.0, is summary of ACB Lighter module handling including handling requirements for heavier than 30 LT modules. Section 6.0, provides a summary of the findings of this Phase II Study and makes recommendations for outstanding critical issues that could be addressed in future phases of ACB Lighter program.

2.0 THE MODULAR ACB LIGHTER CONCEPT

In order to address the inherent limitations of the existing Navy's NL and the Army's Modular Causeway System (MCS), NFESC developed the concept of a new modular Amphibious Cargo Beaching (ACB) Lighter. The new ACB Lighter is to overcome the many limitations of the existing systems in cargo capacity, freeboard, transportability and operating capability in higher than Sea State 2 weather conditions. The existing Navy lighterage must be transported fully assembled on the top side of its transport ships. Only a limited number of lighters can be carried aboard a few suitable classes of ships.

At the present time, the U.S. Navy is procuring a number of modern Roll-On/Roll-Off type Sealift ships to enhance its capability to transport military cargo. At the same time, at the final link of the Navy Sealift chain, when cargo is transported from ship to shore, the existing deficient lighterage systems are used to conduct the crucial Logistics Over The Shore (LOTS) operations.

The new ACB Lighterage System is based on the development of standard modules that will be easy to transport and assemble on site. The size of the proposed modules is 24 ft wide by 40 ft long and 8 ft deep. The 40 ft long modules would be capable of being stacked and transported in standard container ship cell guides and in the container holds of special Navy ships such as the Auxiliary Crane Ship (T-ACS). The in hold container guide interface and the stacking of the ACB Lighter Modules is similar to that of the SEA SHED tween deck modules.

In order to be able to handle the ACB Lighter modules in commercial or military cargo/container terminals with standard container cranes and spreaders with 30 LT safe working load under the spreader, the maximum handling/transportation weight for each lighter module was set at 30 LT as a design objective. This weight limit is the same as the maximum gross weight of a standard 40 ft ISO size cargo container.

Under the ACB Lighter program a series of special modules would be developed for different uses. The modules would be raked (bow/stern), center, power and articulated ramp for beaching. Three 40 ft long modules would be connected in the water, to form a standard 24 ft wide by 120 ft long and 8 ft deep ACB Lighter (see Figures 2-1 and 2-2). The lighter modules would be outfitted with all necessary fittings such as rigid connector assemblies, handling, stacking, cargo tie-down and mooring fittings. The large size ACB Lighters would be capable of carrying a high load of military cargo which will primarily consist of 20 ft or 40 ft long ISO size cargo containers, tanks, Armored Personnel Carriers (APCs), trucks and other military vehicles commonly transported by the Navy Sealift Ships. The new lighter would have higher freeboard 3 ft minimum vs. the 1 ft minimum for the existing lighters and could carry out operations in Sea State 3 weather conditions. The ACB Lighter would be used as a modular building block for the construction of a variety of special purpose causeway ferries (single and double wide) and special platforms. The platforms might include Roll-On/Roll-Off platforms, causeway piers, air cushion vehicle landing platforms and air cushioned transport platforms.

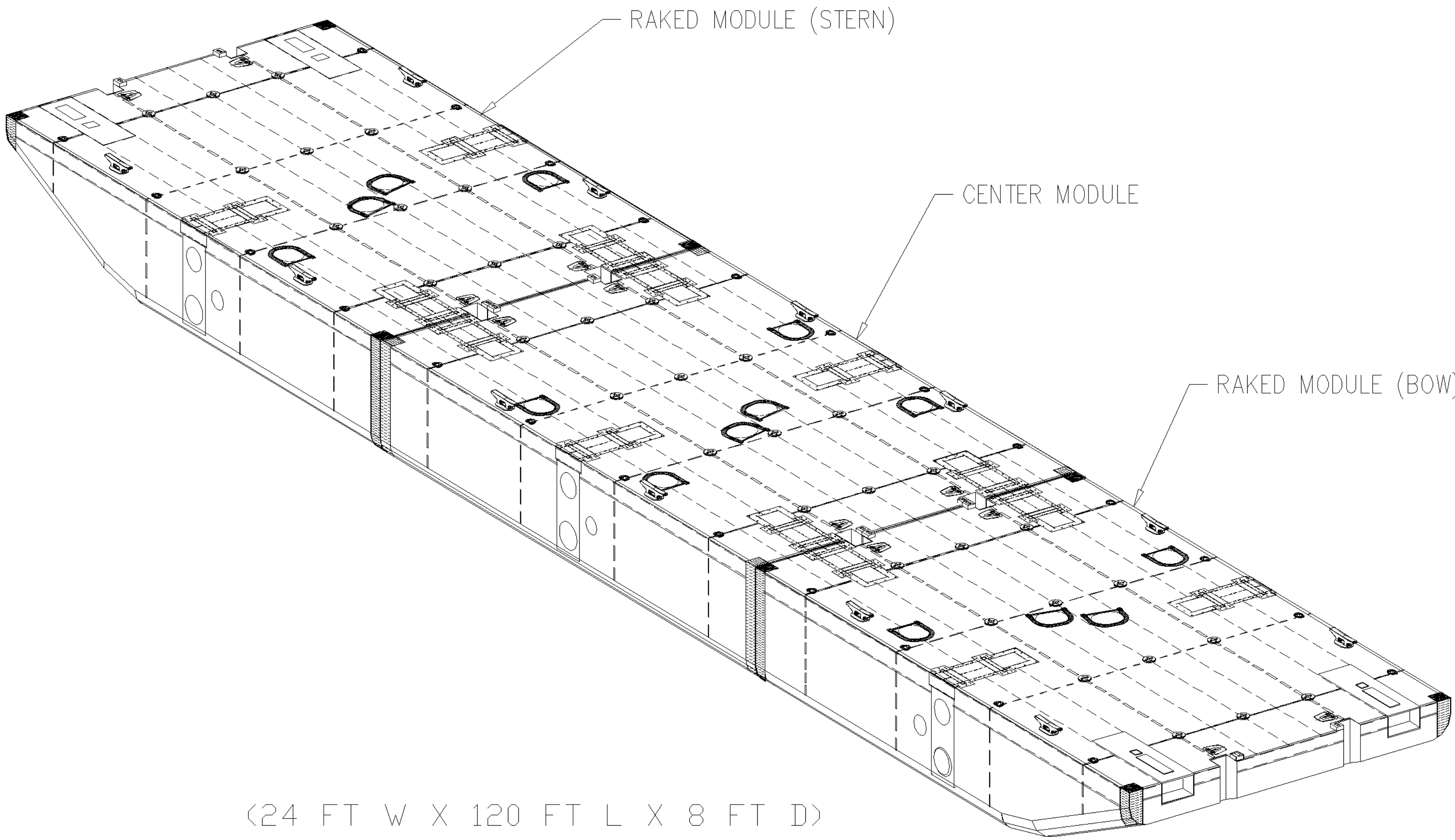


Figure 2-1. Isometric View of Modular ACB Lighter (Unpowered)

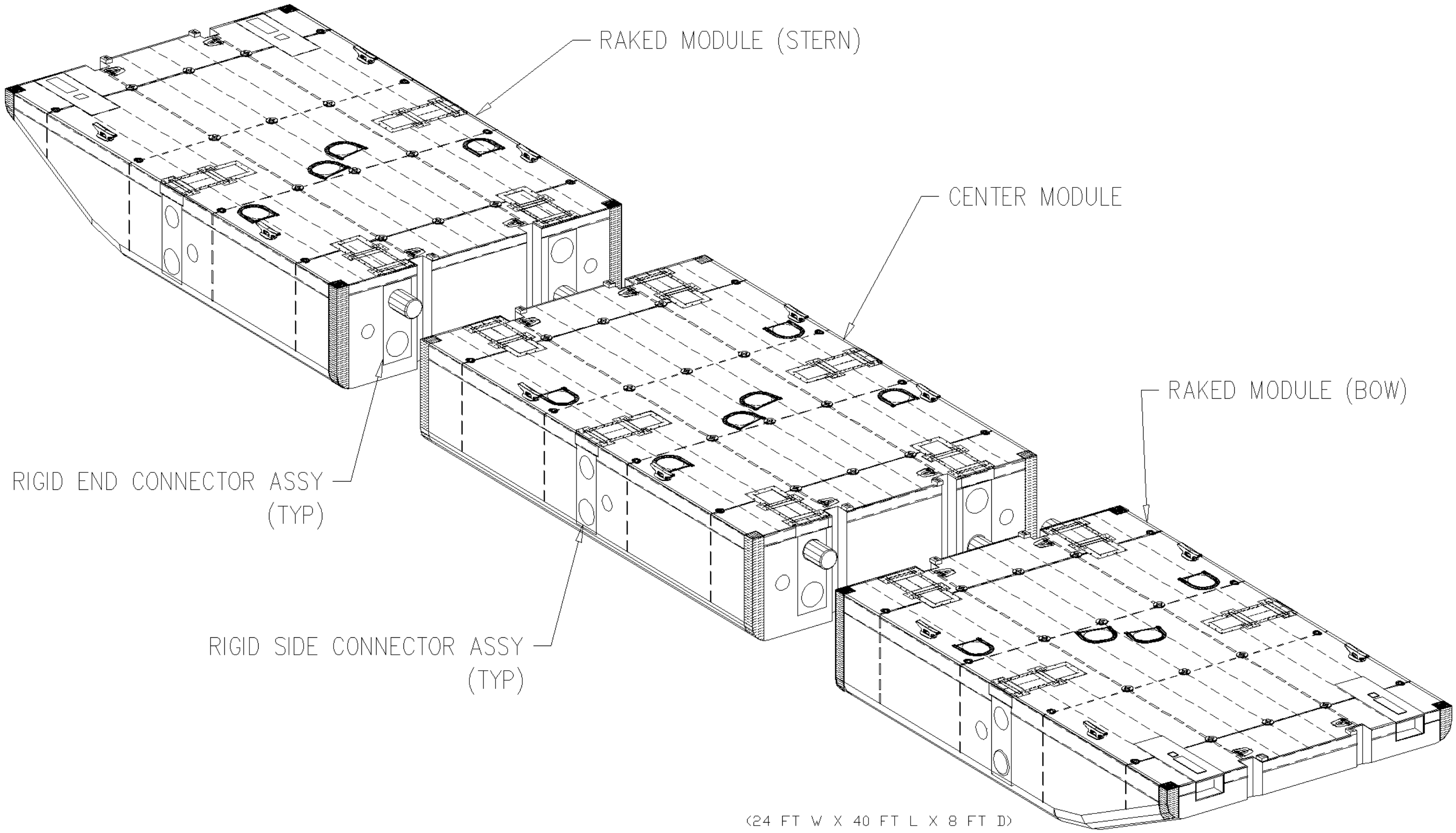


Figure 2-2. Isometric View of ACB Lighter Modules Lined up for Connection

3.0 PHASE II DESIGN DEVELOPMENT OF THE MODULAR ACB LIGHTER

3.1 Background

Due to the weight limitation imposed by standard container terminal handling equipment capacity, the driving objective of the ACB Lighter program has been the development of lightweight lighter modules which can be handled by terminal equipment and transported in container holds. The 24 ft wide by 120 ft long by 8 ft deep ACB Lighter is assembled from three (3) 40 ft long modules which are the constant depth center module and the raked bow and the raked stern modules.

The Phase I design criteria presented in Reference (1) set the maximum gross handling weight, including structure and attached fittings, for each 24 ft wide by 40 ft long by 8 ft deep lighter module, center and raked, at 30 long tons (67,200 lbs), the same as the maximum permissible gross weight of a standard 40 ft long ISO cargo container.

At 30 long ton maximum gross weight, the ACB Lighter modules could be handled in container terminals with standard container cranes and container spreaders, when loading the modules into container holds similarly to the loading of the SEA SHED modules. When stacked in cell guides, the modules would occupy three adjacent container cells.

In accordance with the stated design criteria, the 67,200 lbs maximum handling gross weight of the modules would include the weights of the following components:

- Hull structure
- Cargo tie-down fittings
- Stacking and handling fittings
- Mooring/towing fittings
- Rigid connector assemblies
- Rigid connector recess covers
- Flexor type lighter to lighter connector assemblies (raked module only)

Among the listed fitting groups the weight of the rigid connector assemblies for the module connection is the most significant. The design development of the connectors, shown in Figure 3-15, has been undertaken by the Naval Facilities Engineering Service Center (NFESC) Code ESC31 and others under separate contracts. The NFESC provided weight budget for a rigid connector assembly is 3,000 lbs. This connector weight was used by MR&S for the Phase I study and will also be used for this second phase study.

Due to the fact that existing regulatory agency design guidelines by the American Bureau of Shipping (ABS) and others proved to be mostly inapplicable to the ACB Lighter design, the development of a specific ACB Lighter structural design criteria became necessary. Therefore, the main objective of the Phase I study was to develop the criteria for lightweight module hull design.

Despite considerable progress made in developing the preliminary structural design criteria for the ACB Lighter modules, the Phase I development effort could not achieve the 67,200 lbs maximum allowable weight limit for the lighter module(s). As shown in Tables 3-7.1 and 3-7.2 of Reference (1), the total estimated module weights (scantling and fittings) were 87,975 and 75,031 lbs for the center and raked lighter modules respectively. Therefore, the estimated center and raked module weights exceeded the 67,200 lbs allowable weight limit by 20,775 lbs and 7,831 lbs respectively.

Nevertheless, the objective of this second phase design development study is to find feasible ways to design the lightest possible module structure which is durable and can be reliably operated for the intended service in a Sea State 3 environment while conducting Logistics Over The Shore (LOTS) operations.

Based on the results of the Phase I study, this second phase development effort has set several objectives, listed in Section 1.0, which if achieved, should either bring the module weights down to the maximum allowable limit of 67,200 lbs or reduce the excess weight as much as possible.

3.2 Recommended Hull Structure Design Criteria

The second phase ACB Lighter structural design criteria presented in this study is a modified version of the Phase I preliminary design criteria presented in Reference (1). This second phase modified structural design criteria consists of the following proposed requirements:

3.2.1 Material

All steel plate and shape material to be used in the ACB Lighter construction shall be ABS Grade AH36-HTS having a minimum yield strength of F_Y=51 Ksi and a minimum ultimate strength of F_U=71 Ksi in accordance with Reference (5).

3.2.2 Design Loads

3.2.2.1 Wheel Load

The deck plating of the ACB Lighter shall be designed for the wheel loading of the Rough Terrain Container Handler (RTCH). The design wheel load shall be 75 kips distributed over a 2 ft by 2 ft wheel foot print.

3.2.2.2 Hull Girder Bending Load

The longitudinal hull girder of the ACB Lighter shall be designed for 2,500 kip-ft bending moment and a 110 kip shear load applied at the end of the 40 ft long center module in way of the two rigid connector assemblies, equally distributed between the two end connectors. These loadings, specified in section 5.2.2 of Reference (6), shall be used for preliminary structural design in lieu of the bending moment that may be developed from hydrostatic calculations.

The calculated effective hull girder section modules of the ACB Lighter shall not be less than required by the ABS River Barge Rules, Reference (4). The calculated primary hull girder bending stresses due to the hull girder bending load specified in section 3.2.2.2 shall not exceed the ABS allowable (F_b) bending stress of 28 Ksi for the material specified in section 3.2.1.

3.2.3 Allowable Design Stresses

3.2.3.1 Deck Plating

The deck plating of the ACB Lighter and the top plating of the removable bolted rigid connector recess covers shall be designed for the RTCH wheel load specified in section 3.2.2.1 in accordance with procedures defined in Reference (2), "Design for Deck Structures Under Wheel Loads" by R.I. Jackson & P.A. Frieze. The design procedure is based on the assumption that the top plate stress under the design wheel load may exceed the yield strength of the material and permanent deformation (dishing) of the plating between stiffeners may occur. For the ACB Lighter design the maximum permissible deck plating deformation (dishing) under the specified wheel load is 1/4 inch.

3.2.3.2 Deck Stiffeners

The longitudinal and transverse deck stiffeners of the ACB Lighter shall be designed for the RTCH wheel load specified in section 3.2.2.1. The allowable bending stress (F_b) for this case and the material specified in section 3.2.1 shall be 33.60 Ksi, (*).

> *(*) This allowable stress is 20% higher than the 28 Ksi ABS allowable bending stress for the same material. In order to reduce the weight of the ACB Lighter structure, a main objective of this Phase II design development effort is to verify the feasibility of increasing the ABS allowable stresses for selected ACB Lighter structural members by 20%.*
>
> *The rational for this 20% increase of the ABS allowable bending stress is summarized in the following:*
>
> - *In accordance with the ABS River Barge Rules, Reference (4), the minimum yield strength (F_y) of the specified high strength steel for the ACB Lighter is 51 Ksi. The ABS allowable bending stress (F_b) for the material is 28 Ksi. Therefore, the corresponding ABS factor of safety on the yield strength of the material is equal to 1.82. The ABS allowable bending stress is relatively low compared to the yield strength of the material. Therefore, the ABS rules allow that shipstructures be designed to static load(s). The ABS rules do not calculate and consider the ship motion induced dynamic loads. The effect of the ship motion is taken into consideration by the low allowable stress. In general, due to this conservative approach shipstructures designed to ABS rules tend to be heavy.*
>
> - *On the other hand, in accordance with 0900-LP-097-4010, "Structural Design Manual for Naval Surface Ships", 1976, Reference (3), the Navy allowable bending stress (F_b) for the same high strength steel is 36.9 Ksi.*

Thus the corresponding Navy Factor of Safety (F.S) on the yield strength of the material is equal to 1.38. However, this Navy allowable stress does not include any margin for the effect of ship motion. In general, for design purposes the Navy' approach takes the ship motion effect into consideration by using a larger design load which is the sum of the static load and the ship motion induced dynamic load.

The Navy design load is usually calculated by multiplying the static load with an applicable load factor which corresponds to the specified operating Sea State. The applicable vertical load factor, representing the ship motion effect in the vertical plane is about 1.5 for Sea State 8 (storm sea condition) and about 1.25 for Sea State 5 (moderate sea condition). Since the specified operating Sea State for the ACB Lighter is Sea State 3, the applicable vertical load factor due to ship motion is about 1.13, which represents a 13% increase in the static load. This increased static load could be used in conjunction with the higher Navy allowable stress to design the structure. Also for the same effect, the 13% load increase represented by the load factor can be added to the already calculated Navy factor of safety (S.F. = 1.38) to obtain a new effective factor of safety for the Sea State 3 operating condition. Thus the new factor of safety, $S.F.^{'} = 1.38 + 0.13 = 1.51$. Hence the new allowable bending stress for Sea State 3 operating condition is $F_b^{'} = F_y/S.F.^{'} = 51$ Ksi/1.51 = 33.77 Ksi based on the Navy criteria. This Navy allowable stress level is practically the same as increasing the 28 Ksi ABS allowable stress by 20%, that is $F_y^{'} = 28$ Ksi x 1.2 = 33.60 Ksi. The two stress levels are in very close agreement. Therefore MR&S recommends that the proposed 33.60 Ksi allowable bending stress be adapted for selected structural members of the ACB Lighter design. Thus the static load(s) can be used with this allowable stress to design the structure. The following ACB Lighter structural components shall be designed to the $F_b^{'} = 33.6$ Ksi allowable bending stress:

- *Longitudinal and transverse deck stiffeners (see section 3.2.3.2)*
- *Foundations and supporting structures in way of the rigid connector installations (see section 3.2.3.3)*

3.2.3.3 Foundations and Supports

Foundation structures in the rigid connector recesses of the hull and the support structures of the removable (bolted) rigid connector recess covers shall be designed for the connector imposed loadings specified in section 3.2.2.2. The allowable bending stress (F_b) for this case and the material specified in section 3.2.1 shall be 33.6 ksi, (*For the rational on the specified allowable bending stress see (*) in section 3.2.3.2).*

3.2.3.4 Hull Plating, Hull Stiffeners and Frames

a. In accordance with Part 3, Section 4 of the ABS rules in Reference (4) the end, side and bottom plating of the ACB Lighter hull shall be 1/4 inch.

b. The following hull stiffeners and frame structures shall be in accordance with minimum ABS size requirements of Part 3, Section 4 in Reference (4):

- Side longitudinals and transverses
- Bottom longitudinal and transverses
- End stiffeners
- Stanchions and diagonals of the longitudinal and transverse bulkhead frames

(Note: The upper chords of the bulkhead frames shall be designed in accordance with section 3.2.3.2)

3.2.3.5 Watertight Bulkhead Platings

The longitudinal and transverse watertight bulkhead platings of the ACB Lighter shall be 3/16 inch, the same as the minimum allowable plate thickness calculated by the ABS Rules in Reference (4). *(Note: The ABS requirement that the calculated bulkhead plate thickness be increased to a 1/4 minimum thickness shall not be complied with for the ACB Lighter design).*

3.3 Phase II Estimated Hull Scantlings and Weights

In order to verify the magnitude of the attainable hull structure weight savings, relative to the Phase I Study results, MR&S performed a preliminary scantling design and weight estimate of the ACB Lighter hull structure. The preliminary design was performed in accordance with the recommended structural design criteria presented in Section 3.2 of this study.

The calculated scantling sizes for the center and raked modules are shown in Figures 3-1 and 3-2 respectively.

The comparison study made between the Phase I and Phase II estimated scantling weights of the center or raked module structures is presented below. The Phase I estimated scantling weights are taken from Tables 3-5.8 and 3-5.9 of Reference (1), the comparable Phase II estimated scantling weights are listed in Tables 3-1 and 3-2 of this report.

Comparison of Phase I and Phase II estimated scanting weights:	Center Module (lbs)	Raked Module (lbs)
a. Estimated Phase I Basic Scantling Wt *(*)*:	58,411	54,811
b. Estimated Phase II Basic Scantling Wt *(*)*:	53,544	50,245
c. Estimated Phase II Basic Scantling Wt Inc/(Dec), (a-b):	(4,867)	(4,566)
d. Estimated Phase II Recess & Foundation Wt:	11,430	8,088
e. Total Estimated Phase II Scantling Wt (b+d):	64,974	58,333
f. Total Estimated Phase II Scantling Wt Inc/(Dec), (e-a):	6,563	3,522

(*) Does not include the weight impact at the connector recesses and related foundations.

The results indicate that the comparable basic scantling weight of the center and raked module structures were reduced in the Phase II preliminary design by 4,867 lbs and 4,566 lbs, respectively.

The reductions in scantling weights were made possible by the revised design criteria in Section 3.2.3.2. This criteria specifies a 20% higher allowable bending stress than the Phase I allowable bending stress. The results met the Phase II objectives for basic structural weight reduction. However, in this study MR&S also made a realistic assessment of the structural weight impact for the connector recesses and foundations in way of the rigid connector assembly installations. Due to the large size of the recesses (see Figures 3-3 and 3-4) and the large connector imposed loadings on the structure the impact on the structural weight was found to be considerable. MR&S estimated the net structural weight increases caused by the recesses and the built-in connector foundations. The estimated weights are listed in Tables 3-1 and 3-2 as 11,430 lbs for the six (6) center module recesses and 8,088 lbs for the four (4) raked module recesses. These additional structural weights raise the total estimated scantling weights of the center and raked module structures to 64,974 lbs and 58,333 lbs respectively. Thus the connector recess related structural weight increases, which were not calculated in the Phase I Study, have increased the Phase II estimated total scantling weights of the center and raked module structures by 6,553 lbs and 3,522 lbs over the corresponding Phase I weights.

3.4 Hull Systems and Fittings

3.4.1 Connectors

The Modular ACB Lighter utilizes the following types of connector systems:

a. Rigid End Connector Assemblies, (Figure 3-15). Rigid connector assemblies under development by NFESC, Reference (8), will be used for end to end connection of the three basic 40 ft long lighter modules (raked bow, center and raked stern) when assembling them into a 120 ft long ACB Lighter as illustrated in Figures 3-16 and 3-17.

   The center module will have two rigid end connector assemblies installed at each end as shown in Figures 3-20 and 3-21. The raked module will have two rigid end connector assemblies at the 8 ft deep connection end only as shown in Figures 3-22 and 3-23.

b. Rigid Side Connector Assemblies (Figure 3-15). Rigid side connector assemblies, identical to the end connectors, will be used for side to side connection of ACB Lighters as illustrated in Figures 3-16 and 3-18.

   As shown, each center module and raked module will have one rigid side connector assembly installed at each side, at the mid-length of the 40 ft long modules.

c. Flexible Alignment Pin Assemblies (Figures 3-17 and 3-18). Flexible alignment pin assemblies under development by NFESC, Reference (9), will be used in conjunction with the rigid connectors to prealign the modules before the rigid connector pins are engaged with the receptor tubes as illustrated in Figures 3-17 and 3-18. At each connector recess location in the hull structure, 30 inches off the centerline of the recess, a welded alignment pin receptor tube is provided to house the alignment pins as shown in Figures 3-3 and 3-4.

d. Flexor Type Connectors, similar to the existing NL Flexor units for flexible end to end connection of ACB Lighters when assembling causeway ferries from two or more lighters. Two flexor type connector assemblies will be installed at the raked end of each raked bow/stern module as shown in Figures 3-22 and 3-23.

   It is estimated by NFESC Code ESC31 that the yet to be developed ACB Flexor connectors will be approximately 33% larger in size than the existing NL Flexor connectors.

The design development of the ACB Lighter Rigid Connector System, including the flexible alignment pin assembly, is expected to be completed in the near future by NFESC and others under separate contracts. Therefore at the present time final connector weights are not available. For arrangement and weight estimating purposes based on NFESC Code ESC31 provided information and MR&S estimates the following weight budgets were used for the various connectors:

- As shown in Figure 3-15 each rigid end and side connector module will be 2 ft wide by 6 ft long (planview) and 6 ft high. Based on information contained in Reference (8) MR&S allocated 3,000 lbs for each rigid end and side connector module.

- Based on information contained in Reference (9) MR&S allocated 600 lbs per flexible alignment pin assembly in the weight estimate of the ACB Lighter.

- For the flexor type connectors MR&S allocated 1,000 lbs per connector unit in the weight estimate for the ACB Lighter.

For total allocated connector and flexible alignment pin assembly weights for the center and the raked module of the ACB Lighter see Tables 3-4.1 and 3-4.2 respectively.

For the general arrangement of the connector assemblies in the ACB Lighter modules see Figures 3-20 and 3-21 for the center module and Figures 3-22, 3-23 and 3-24 for the raked module.

3.4.1.1 Rigid Connector Recess (RCR) Cover

The removable connector assemblies will be installed on foundations provided at the bottom structure and on the side bulkheads of the recesses in the hull. The configuration of the connector recess structure is shown in Figures 3-3 and 3-4 for a typical end and side recess respectively. The installation interface of a typical connector assembly in the hull recess in shown in Figure 3-16. As shown, when the connector assembly is installed, the foundations in the recesses provide support for the connector imposed loadings during lighter operation in the sea way (see Section 3.2.2.2).

The topside support for the connector is provided by the removable (bolted) recess cover structure shown in Figures 3-5. When bolted in place at the top of the recess, the four built in supports of the cover will clamp down on the four support columns in the connector frame. When installed the top plate of the cover is flush with topside of the lighter module deck plating. While the cover structure is designed for the connector imposed loadings, the top plate of the cover also designed to support the wheel loading of the RTCH. In order to facilitate the deployment/retraction of the connector pin by the crew the bolted recess cover is provided with two integral access covers in the top plate. These access covers allow the crew to operate the connector pin actuation lever and to remove and install the Guillotine type locking plates of the connector pin. The MR&S estimated weight budget for the RCR cover shown in Figure 3-5 is 860 lbs.

3.4.2 ISO Container Fittings

3.4.2.1 Center Module

As shown in Figure 3-6 the 40 ft long center module of the ACB Lighter will be fitted, top and bottom, with standard ISO container fittings. The four top container fittings (Figure 3-8) and the four bottom container fittings (Figure 3-9) will be integrated in the center module structure in accordance with ISO STD 668. The fittings will be located about the longitudinal centerline of the module in a pattern identical to that of a 40 ft long STD ISO container.

The installation of the corner fittings in the center module will provide the following capabilities:

1. Handling of the module with a 40 ft container spreader as shown in Figures 5-1 and 5-2. When handling the Lighter module with a spreader equipped container crane or boom type heavy lift crane during container hold loading/unloading operations, the four (4) twist locks on the spreader frame will engage the topside container corner fittings on the module.

2. Secure inside container terminal transportation of the module while being transported to the pierside by a 40 ft container trailer or a flat-bed truck. The module

will be secured during transportation by the four (4) twist locks on the trailer frame engaging the bottom container fittings of the module.

3. The container fittings will provide the four (4) top and bottom load bearing points when the modules are stacked on shore or in the container guides of a ship's container hold. The fittings can support a maximum of six module high stack in the guides.

3.4.2.2 Raked Module

As shown in Figure 3-7 the 40 ft long raked module of the ACB Lighter will be outfitted on the topside with four (4) standard ISO container corner fittings similarly to topside of the center module described in Section 3.4.2.1. The bow/stern end of the raked module is tapered to a 2'-9" depth as compared to the 8'-0" full depth of the connection end. Thus, the bottom corners of the raked end will be 5'-3" higher than the bottom corner fittings at the full depth end. Therefore, on the raked module only the two bottom corner fittings at the full depth end will be provided. Hence, the bottom corner fitting arrangement on the raked module does not match the topside corner fitting arrangement on the center module. In order to resolve potential transportation and stacking interface problems caused by the different corner fitting patterns, in addition to the two bottom corner fittings, two intermediate support pads were also added on the bottom of the raked module (see section 3.4.3).

3.4.3 Stacker Fittings

The 120 ft long modular ACB Lighter is assembled from a set of 40 ft long lighter modules. Each three module lighter set consists of two raked bow/stern modules and one center module. The lighter modules will be stacked in sets either while being stored (stockpiled) at shoreside loading terminal facilities or as illustrated in Figure 4-2, will be stacked in the cell guides of a cargo hold while being transported in containerships. In order to ensure proper load transfer between the tiers of stacked modules and between the stack of modules and the support structure (foundation) at the shoreside or in the ship, the modules are outfitted with a set of stacker fittings.

The recommended stacker fitting arrangement for the center and raked modules are described in sections 3.4.3.1 and 3.4.3.2 respectively.

3.4.3.1 Center Module

As shown in Figure 3-6, the center module is outfitted with the following stacker fittings:

a. In addition to the module handling function described in Section 3.4.2, the four topside ISO container corner fittings can also be used as stacker fittings. All four container fittings are used when two center modules are stacked on each other. Only two out of four container fittings are used when a raked module is stacked on the topside of the center module.

b. As shown in View A of Figure 3-6, in addition to the four ISO container corner fittings, four special raised cargo tie down fittings are also provided on the topside of the center module. These four dual purpose cargo tie down fittings are installed on a 1/2 thick base plate and are also utilized as stacker fittings when a raked module is stacked on the topside of a center module. Only two ISO container corner fitting and two raised tie down/stacker fittings are required to support a raked module. A total of four base plate mounted raised tie down/stacker fittings are provided on each center module to allow the top side stacking of a raked module either with its bow oriented forward or oriented aft as shown in Figure 4-2.

c. As shown in Figure 4-2, the four bottom ISO container corner fittings on the center module are used as stacker fittings. The bottom container corner/stacker fitting pattern on the center module is identical to that of a 40 ft STD ISO container. When the lighter modules are stacked at the shoreside or in the cargo hold of a containership, a center module should always be used at the bottom of the stack to provide a four point support for the stack load. When loaded in the container hold the four bottom fittings of the center module will directly transfer the stack load to the tank top mounted container support pads in the hold. The bottom stacker fittings can also be used for stacking one center module on the top of an other center module or on the top of a raked module.

3.4.3.2 Raked Module

As shown in Figure 3-7, the raked module is outfitted with the following stacker fittings:

a. The topside stacker fitting arrangement of the raked module is identical to the topside stacker fitting arrangement of the center module described in Section 3.4.3.1 (a) and 3.4.2.1 (b).

b. As shown in Section A-A of Figure 3-7, the two bottom ISO container corner fittings installed at the full depth end of the raked module are used as stacker fittings. In order to provide a total of four bottom stacker fittings, two additional stacker plates are provided on the underside of the raked module. As shown, the stacker plates are located 25 ft from the full depth end of the module.

When loaded on the topside of the center module, the two bottom stacker plates of the raked module interface with two of the four special raised tie down/stacker fittings on the center module as shown in Section B-B of Figure 4-2. The stacker plates also interface with the raised tie down/stacker fittings installed on the topside of the raked module when raked modules are stacked on each other.

3.4.4 Lift Fittings

In addition to the four topside standard ISO corner fittings for handling the module with a container spreader as described in Section 3.4.2, a secondary set of four (4) hinged lifting pads (Figure 3-10) are provided on each lighter module (center and raked) as shown in figures 3-20 and 3-21. When handling, the four hinged lifting pads on the module will be attached to a four-point wire rope sling as shown in Figure 5-2.

3.4.5 Cargo Tie Down Fittings

Cargo tie down fittings will be required to secure the cargo on the deck on an ACB Lighter, or aboard causeway ferries assembled from ACB Lighters, when transporting cargo ship to shore during LOTS operations.

It is anticipated that the cargo will primarily consist of 20 ft or 40 ft long cargo containers, tanks, APCs, trucks and other military vehicles commonly transported by the Navy’s Sealift Ships. One of the objectives was to select suitable fitting(s) which can be used for the tie down of all anticipated containerized and vehicular cargos on the deck of the ACB Lighter. Ideally, the selected fitting(s) would also be compatible with the type of tie down fittings and cargo tie down lashings used on the new Navy Sealift Ships under construction. During the Phase I effort of this study, MR&S evaluated the relative advantages and disadvantages of selecting raised type vs. flush type cargo tie down fittings for the ACB Lighter. The detailed comparison of the two fitting type options is presented in Section 3.2.4 of Reference (1). Based on that evaluation and on the review of the options conducted in this Phase II effort, MR&S recommends that the raised type tie down fittings be used on the ACB Lighters. The recommended tie down fitting arrangements for the center and raked modules are shown in Figures 3-6 and 3-7 respectively.

As shown in the arrangements, two different types of raised tie down fittings were selected for the ACB Lighter. These are the Raised Cloverleaf Deck Socket type (see Figure 3-11) and the Raised Cloverleaf D-Ring and Strap type (see Figure 3-12). On each type of lighter module, center and raked, a total of eight Raised D-Ring type fittings will be installed along the port and starboard side deck edges. The inboard of the deck will be fitted with twelve Raised Cloverleaf Sockets as shown to provide the required flexibility for cargo spotting and securing. Four of the Raised Cloverleaf Sockets, at the center area of the deck, will be installed on baseplates. These baseplate mounted tie down fittings may also be used as stacker fittings during storage or transportation as described in Section 3.4.5.

The tie down deck fittings are located for easy integration with the module structure to minimize added weight needed for structural reinforcement. The D-Rings are aligned with the transverse bulkheads at the hull sides, port and starboard. The Cloverleaf Sockets are coincident with the intersection of the transverse bulkheads and the longitudinal bulkheads, port and starboard, or the C.L. deck girder as shown in Figures 3-6 and 3-7.

The selected tie down fittings for the ACB Lighter are of the same cloverleaf type as the fittings used on the Navy’s Sealift Ships but are smaller in size and capacity. Tentatively in this study MR&S selected fittings with 35,000 lbs breaking strength instead of the 70,000 lbs rating for the fittings on the Sealift Ships. This reduction in strength is justified by the fact that the cargo tie down fittings aboard the Sealift ships must withstand loads associated with open ocean transit conditions of sea state 8 (sea storm condition) while the ACB Lighter will typically operate in conditions not exceeding sea state 3. The smaller and lighter fittings also reduce the weight of the modules.

However, it is recommended that during the future stages of the ACB Lighter development the selection of the 35,000 lbs capacity rating for fittings be verified by a more detailed cargo tie down study using pertinent lighter cargo and ship motion data.

The standard tie down lashings are available in adjustable length wire rope or chain types with a variety of end connections to suit the cargo units and the selected deck fittings. The breaking strength of the lashings shall match the strength of the deck fittings. The exact mix of lashing assemblies to be carried with the ACB Lighter remains to be determined. A typical example of a suitable tie down assembly is shown in Figure 3-13.

3.4.6 Mooring/Towing and Anchoring

3.4.6.1 Mooring/Towing Fittings

Various types of deck fittings (bitts, chocks, cleats etc.) will be required on the ACB Lighter modules for mooring and waterborne handling/towing of individual modules, assembled lighters, causeway ferries and special platforms constructed from lighters. In order to select the lightest and most efficient mooring/towing fittings for the ACB Lighter, MR&S evaluated various available fitting types for suitability. The objective was to keep the number of fitting installations to a minimum without reducing operational capabilities. Based on the evaluation, MR&S selected a removable kevel cleat type multipurpose fitting for the ACB Lighter (see Figure 3-14).

The kevel cleat is a combination of a cleat and chock and is suitable for handling, fairleading and securing synthetic ropes during mooring and waterborne operations and for securing wire rope from winches when moored and positioned alongside ships.

The kevel cleats must be removed from the modules when the modules are stacked ashore or being transported in container cells.

The removable kevel cleats (see Figure 3-14) will be stowed onboard the module transport ship and installed, as required, prior to off loading the modules at sea. The removal of the cleats will reduce the stacking depth of the modules to the required 8'-0". In addition, the removal of the cleats will result in weight reduction of the modules during handling and stacking. (See Item 16 of Tables 3-4.1 and 3-4.2 for the center and raked modules respectively). This feature will require additional logistic support, including labor for handling and installation at the site, also stowage provisions must be provided by the module transporting ship.

At the present time, it is estimated that four (4) removable kevel cleats, two (2) each side, will be required for each module, with each kevel cleat having an estimated weight of two hundred and fifty (250) pounds, as indicated in Tables 3-4.1 and 3-4.2. The actual weight of the kevel cleat along with the required cleat size and capacity can only be determined by performing detailed mooring and towing calculations for the anticipated ACB Lighter operating scenarios. These calculations should be performed during the detail design phase.

3.4.6.2 Mooring Lines

U.S. Navy ships are presently using polyester and arimad mooring lines, with most of the newer ships being outfitted with arimad lines by the ship builder in accordance with ship specifications. A few Navy ships which were backfitted with arimad lines, have reverted back to using polyester lines, based on their own preferences. Each type of line has its own advantages and disadvantages, which must be addressed when based on mooring/towing calculations the actual lines will be selected during detail design.

3.4.6.3 Anchoring

While the development of a suitable anchoring arrangement for the ACB Lighter and the selection of anchor sizes and required system components are not part of this study the following pertinent information is provided. Presently, both the U.S. Army and the U.S. Navy have similar procedures for anchoring lighters offshore. That is, the bitter end of the anchor cable securing chain is connected to the chain plate, the tending craft casts off to a point perpendicular to the causeway and places the anchor. The exact placing of anchors is dependant on the prevailing environmental conditions. While the U.S. Navy utilizes an array of lightweight anchors ranging between five hundred (500) to three thousand (3,000) pounds, the U.S. Army uses two thousand (2,000) pound NAVMOOR anchors. Anchor size, tandem anchors and quantity of anchor mooring legs are dependant on environmental conditions and quantity of lighters in the causeway make-up.

3.5 Modular ACB Lighter Assembly

The general arrangement and key dimensions of the Modular ACB Lighter, developed by MR&S in this Phase II preliminary study is shown in Figure 3-19. The estimated lightship weight of the fully outfitted ACB Lighter is given in Table 3-4.

The 24 ft wide by 120 ft long by 8 ft deep(*) ACB Lighter is assembled from the following 40 ft long basic modules:

a. One (1) Center Module Assembly. The general arrangement of the center module is shown in Figures 3-20 and 3-21. The estimated lightship weight of a fully outfitted center module is given in Table 3-4.1.

b. Two (2) Raked Module Assemblies (Bow and Stern). The general arrangement of a typical raked module is shown in Figures 3-22, 3-23 and 3-24. The estimated lightship weight of a fully outfitted raked module is given in Table 3-4.2.

(*) As shown in Figures 3-6 and 3-7 for the center and raked modules respectively, the full stacking depth of the modules is 8'-0". The stacking depth of the modules, when the mooring cleats are removed, is measured between the top side of the top corner fittings and the bottom surface of the bottom corner fittings as shown. In order to accommodate the installation of the raised type tie down fittings and to provide the necessary clearance between the contact

surfaces of the stacker/corner fittings and the hull structure the effective hull scantling depth of the ACB Lighter modules is 7-8 1/2".

TABLE 3-1
ACB LIGHTER "CENTER MODULE"
(24FT W X 40FT L X 8FT D) (*)
ESTIMATED SCANTLING WEIGHTS
BASED ON:
RECOMMENDED ACBL DESIGN CRITERIA IN ACCORDANCE WITH SECTION 3.2
DECK LONGITUDINAL SPACING: 29" - TRANSVERSE FRAMING: 10 FT MAX.

REDUCED MODIFIED SCANTLINGS IN BOLD ITALIC

	Qty	Description	Plate Dimensions t (in)	W (ft)	L (ft)	Stiffener L (ft)	Conversion Factor	Total Wt. (lbs)	From Bottom VCG (FT)	From Transv CL LCG (FT)	From Longl CL TCG (FT)
(**)	1	***Deck Plate 1/4"***	0.25	24	40		40.8	9792	8	0	0
	2	Side Plate 1/4"	0.25	6.86	40		40.8	5598	4	0	0
	1	Bottom Plate 1/4"	0.25	24	40		40.8	9792	0	0	0
	2	End Plate 1/4"	0.25	6.34	24		40.8	3104	4	0	0
	11	Deck Long'l 14 x 5 x 22# I/T plus 2				40	16.16	7110	8	0	0
	8	Side Long'l 5 x 3 x 1/4 L				40	6.6	2112	4	0	0
	7	Bottom Long'l 6 x 4 x 7 #T				40	7	1960	0	0	0
	14	End Stiff 6 x 4 x 7 #T Minus 4				6.34	7	621	4	0	0
	4	End Stiff 14 x 5 x 22# I/T				5.71	16.16	369	4	0	0
	4	Deck Transv 14 x 5 x 22# I/T				24	16.16	1551	8	0	0
	12	Side Transv 10 x 4 x 15# I/T				5.71	11.26	772	4	0	0
	4	Btm Transv 14 x 5 x 22# I/T				24	16.16	1551	0	0	0
	2	Longl Edge Capping 14 x 5 x 22# I/C				40	16.16	1293	8	0	0
	4	Transv Edge Capping 10 x 4 x 15#I/C				24	11.26	1081	8	0	0
	8	Stanchions 10 x 4 x 17# I				5.71	17	777	4	0	0
	16	Diagonals 6 X 4 X 9 # I				10.21	9	1470	4	0	0
	2	***WT Long'l Bulkhead Plates 3/16"***	0.188	5.71	39.51		40.8	3461	4	0	0
	2	***No Plt iwo stan & Diag of transv bhd***	-0.188	0.83	71.52		40.8	-911	4	0	0
	2	***WT Transv Bulkhead Plates 3/16"***	0.188	5.71	23.3		40.8	2041	4	0	0

A. ESTIMATED "BASIC" SCANTLING WT: (***) 53544 4.56 0.00 0.00
B. NET RCR FOUNDATION WT FOR (6) RCRs: (****) 11430
C. TOTAL EST CENTER MODULE SCANTLING WT: 64974 lbs

NOTES:
(*) FULL STACKING DEPTH OF MODULE IS 8'-0", HULL (SCANTLING) DEPTH OF MODULE IS 7'-8 1/2" AS SHOWN IN FIGURE 3-6
(**) GOVERNING DECK DESIGN WHEEL LOAD 75 KIPS ON 2' X 2' SQUARE (RTCH), SEE SECTION 3.2 FOR ADDITIONAL REQUIREMENTS
(***) "BASIC" SCANTLING WEIGHT OF COMPONENTS LISTED IN TABLE 3-1, WITHOUT RIGID CONNECTOR RECESSES (RCRs) AND RELATED FOUNDATIONS
(****) THE CENTER MODULE HAS A TOTAL OF (6) RCRs, (4) END AND (2) SIDE. THE NET WEIGHT INCREASE FOR (6) RCRs = (4) END + (2) SIDE = 4 X 1671 LBS + 2 X 2373 LBS = 11430 LBS. FOR SCANTLING ARRANGEMENTS SEE FIGURES 3-1, 3-3 AND 3-4.

TABLE 3-2
ACB LIGHTER "RAKED MODULE"
(24FT W X 40FT LG X 8 FT D TAPERED TO 2.75FT @ RAKED END) (*)
ESTIMATED SCANTLING WEIGHTS
BASED ON:
RECOMMENDED ACB LIGHTER DESIGN CRITERIA IN ACCORDANCE WITH SECTION 3.2
DECK LONGITUDINAL SPACING 29" - TRANSVERSE SPACING 10FT MAX.

REDUCED MODIFIED SCANTLINGS IN BOLD ITALIC

	Qty	Description	Plate Dimensions			Stiffener	Conversion	Total Wt.	From Bottom	From 8' Depth End	From CL
			t (in)	W (ft)	L (ft)	L (ft)	Factor	(lbs)	VCG (FT)	LCG (FT)	TCG (FT)
(**)	1	***Deck Plate 1/4"***	0.25	24	40		40.8	9792	8	20	0
	2	Side Plate 1/4"	0.25	6.86	26.33		40.8	3685	4	13.4	0
	2	Side Plate 1/4"	0.25	4.11	13.67		40.8	1146	5.33	33.4	0
	1	Bottom Plate 1/4"	0.25	24	41.07		40.8	10054	0	20	0
	1	End Plate 1/4" (Full Depth End)	0.25	6.34	24		40.8	1552	4	0	0
	1	End Plate 1/4" (Raked End)	0.25	0.84	24		40.8	206	6.75	40	0
	11	Deck Long'l 14 x 5 x 22# I/T				40	16.16	7110	8	20	0
	8	Side Long'l 5 x 3 x 1/4 L				26.33	6.6	1390	4	13.4	0
	8	Side Long'l 5 x 3 x 1/4 L				11.12	6.6	587	5.33	33.4	0
	7	Bottom Long'l 6 x 4 x 7#T minus 2				41.07	7	2012	0	20	0
	7	End Stiff 6 x 4 x 7#T				6.34	7	311	4	0	0
	7	End Stiff 6 x 4 x 7#T				0.84	7	41	6.75	40	0
	2	End Stiff 14 x 5 x 22# I/T				5.71	16.16	185	4	0	0
	2	End Stiff 14 x 5 x 22# I/T				0.21	16.16	7	6.75	40	0
	4	Deck Transv 14 x 5 x 22# I/T				24	16.16	1551	8	20	0
	8	Side Transv 10 x 4 x 15# I/T				5.71	11.26	514	4	11.25	0
	4	Side Transv 10 x 4 x 15# I/T				2	11.26	90	6.75	35	0
	4	Btm Transv 14 x 5 x 22# I/T				24	16.16	1551	0	20	0
	2	Long'l Edge Capping 14 x 5 x 22# I/C				40	16.16	1293	8	20	0
	4	Transv Edge Capping 10 x 4 x 15#I/C				24	11.26	1081	8	20	0
	6	Stanchions 10 x 4 x 17# I				5.71	17	582	4	15	0
	2	Stanchions 10 x 4 x 17# I				2.63	17	89	6.75	35	0
	12	Diagonals 6 X 4 X 9 # I				10.21	9	1103	8	15	0
	7	Verticals 4 x 4 x 5/16 L				4.88	8.2	280	6.75	35	0
	2	***WT Long'l Bulkhead Plates 3/16"***	0.188	5.71	26.29		40.8	2303	4	13.4	0
	2	***WT Long'l BHD Plates 3/16"***	0.188	2.96	13.22		40.8	600	6.75	33.4	0
	2	***No Plt iwo stan & Diag of transv bhd***	-0.188	0.83	71.52		40.8	-911	4	25	0
	2	***WT Transv Bulkhead Plates 3/16"***	0.188	5.71	23.3		40.8	2041	4	15	0

A. ESTIMATED "BASIC" SCANTLING WT:	(***)	50245		4.78	18.53	0.00
B. NET RCR FOUNDATION WT FOR (4) RCRs:	(****)	8088				
C. TOTAL EST RAKED MODULE SCANTLING WT:		58333	lbs			

NOTES:
(*) FULL STACKING DEPTH OF MODULE IS 8'-0", HULL (SCANTLING) DEPTH OF MODULE IS 7'-8 1/2" AS SHOWN IN FIGURE 3-7
(**) GOVERNING DECK DESIGN WHEEL LOAD 75 KIPS ON 2' X 2' SQUARE (RTCH), SEE SECT 3.2 FOR ADDITIONAL REQUIREMENTS
(***) "BASIC" SCANTLING WEIGHT OF COMPONENTS LISTED IN TABLE 3-2, WITHOUT RIGID CONNECTOR RECESSES (RCRs) AND RELATED FOUNDATIONS
(****) THE RAKED MODULE HAS A TOTAL OF (4) RCRs, (2) END AND (2) SIDE. THE NET WEIGHT INCREASE FOR (4) RCRs = (2) END + (2) SIDE = 2 X 1671 LBS X 2 X 2373 LBS = 8088 LBS. FOR SCANTLING ARRANGEMENTS SEE FIGURES 3-2, 3-3 AND 3-4.

TABLE 3-3

ESTIMATED WEIGHTS OF WELDED HULL FITTINGS

SEE	FITTINGS	UNIT WT (LBS)	CENTER MODULE (CM)		RAKED MODULE (RM)	
			QTY	TOTAL WT PER CM (LBS)	QTY	TOTAL WT PER RM (LBS)
FIG. 3-8	Top Corner Ftg	27	4	108	4	108
FIG. 3-9	Bottom Corner Ftg	27	4	108	4	108
FIG. 3-10	Lifting Pad	93	4	372	4	372
FIG. 3-11	Raised Dk Socket	40	8	320	8	320
NOTE (1)	Raised Dk Socket/Stacker	47	4	188	4	188
FIG. 3-12	Raised D-Ring	18	8	144	8	144
NOTE (1)	Stacker Pl	23	--	--	2	46
NOTE (2)	Kevel Cleat Foundation	120	4	480	4	480
FIG. 3-3	Alignment Pin Tube (End)	860	4	3440	2	1720
FIG. 3-4	Alignment Pin Tube (Side)	860	2	1720	2	1720
Total Hull Fitting Weights:				6880 lbs		5206 lbs

NOTES:

1. See Section 3.4.3
2. Weight of kevel cleat foundation only (see Section 3.4.6).

TABLE 3-4

ESTIMATED LIGHTSHIP WEIGHT OF THE MODULAR ACB LIGHTER (UNPOWERED)

ITEM #	DESCRIPTION	QTY PER ACBL	WT PER ACB LIGHTER (LBS)	WT % OF ITEM 5	SEE NOTE
1	Raked (Bow) Module	1	84,659	42.00	1
2	Center Module	1	100,744	49.97	2
3	Raked (Stern) Module	1	84,659	42.00	1
4	Est Lightship WT of ACB Lighter (Items 1, 2 & 3)	1	270,062	133.97	--
5	Design Target WT for ACB Lighter (3 x 30 = 90 LT)	1	201,600	100	--
6	Total Delta Weight (Item 5 - Item 4)	1	68,462	33.97	3

NOTES:

1. See Item 15 of Table 3-4.2
2. See Item 15 of Table 3-4.1
3. Delta weight of 68,462 lbs is in excess of 201,600 lbs, the original design target weight (Item 5) of an assembled ACB Lighter.

TABLE 3-4.1
ACB LIGHTER
SUMMARY OF ESTIMATED WEIGHTS FOR
"CENTER MODULE" (CM)

ITEM #	DESCRIPTION	QTY PER CM	UNIT WT (LBS)	WT PER CM (LBS)	WT % OF ITEM 17	SEE
1	Hull Scantling	1	64,974	64,974	96.69	Table 3-1
2	Welded Fittings	Set	6,880	6,880	10.24	Table 3-3
3	Rigid Connector Assy (End)	4	3,000	12,000	17.86	Sect. 3.4.1
4	Rigid Connector Assy (Side)	2	3,000	6,000	8.93	Sect. 3.4.1
5	RCR Cover (End and Side)	6	860	5,160	7.68	Sect. 3.4.1.1
6	Alignment Pin Assy (End)	2	600	1,200	1.78	Sect. 3.4.1
7	Alignment Pin Assy (Side)	1	600	600	0.89	Sect. 3.4.1
8	Flexor Type Connector Assy	--	--	--	--	--
9	Kevel Cleat (Bolted)	4	250	1,000	1.49	Fig. 3-14
10	Deck Bolster Cover (End)	4	80	320	0.48	Fig. 3-3
11	Deck Bolster Cover (Side)	2	80	160	0.24	Fig. 3-4
12	Welding (1% of Items 1 & 5)	1	700	700	1.04	Note 1
13	Mill Tolerance (1% of Items 1 & 5)	1	700	700	1.04	Note 1
14	Painting (1.5% of Items 1 & 5)	1	1,050	1,050	1.56	Note 1
15	Estimated Lightship Wt of CM (Item 1 thru 14)	1	--	100,744	149.92	--
16	Estimated Handling Wt of CM (Items 15 Less Item 9)	1	--	99,744	148.43	--
17	Design Target WT for Handling	1		67,200	100	Note 2
18	Excess Handling WT of CM (Item 16 Less Item 17)	1	--	32,544	48.43	--

NOTES:

1. Weight budget for welding, mill tolerance and painting is based on shipyard estimating practices.
2. Maximum allowable gross weight of a Std 40 Ft ISO container.

TABLE 3-4.2
ACB LIGHTER
SUMMARY OF ESTIMATED WEIGHTS FOR
"RAKED MODULE" (RM)

ITEM #	DESCRIPTION	QTY PER CM	UNIT WT (LBS)	WT PER CM (LBS)	WT % OF ITEM 17	SEE
1	Hull Scantling	1	58,333	58,333	86.80	Table 3-2
2	Welded Fittings	Set	5,206	5,206	7.75	Table 3-3
3	Rigid Connector Assy (End)	2	3,000	6,000	8.93	Sect. 3.4.1
4	Rigid Connector Assy (Side)	2	3,000	6,000	8.93	Sect. 3.4.1
5	RCR Cover (End and Side)	4	860	3,440	5.12	Sect. 3.4.1.1
6	Alignment Pin Assy (End)	1	600	600	0.89	Sect. 3.4.1
7	Alignment Pin Assy (Side)	1	600	600	0.89	Sect. 3.4.1
8	Flexor Type Connector Assy	1	1,000	1,000	1.49	Sect. 3.4.1
9	Kevel Cleat (Bolted)	4	250	1,000	1.49	Fig. 3-14
10	Deck Bolster Cover (End)	2	80	160	0.24	Fig. 3-3
11	Deck Bolster Cover (Side)	2	80	160	0.24	Fig. 3-4
12	Welding (1% of Items 1 & 5)	1	617	617	0.92	Note 1
13	Mill Tolerance (1% of Items 1 & 5)	1	617	617	0.92	Note 1
14	Painting (1.5% of Items 1 & 5)	1	926	926	1.37	Note 1
15	Estimated Lightship Wt of RM (Item 1 thru 14)	1	--	84,659	125.98	--
16	Estimated Handling Wt of RM (Items 15 Less Item 9)	1	--	83,659	124.49	--
17	Design Target WT for Handling	1	--	67,200	100	Note 2
18	Excess Handling WT of RM (Item 16 Less Item 17)	1	--	16,459	24.49	--

NOTES:

1. Weight budget for welding, mill tolerance and painting is based on shipyard estimating practices.

2. Maximum allowable gross weight of a Std 40 Ft ISO container.

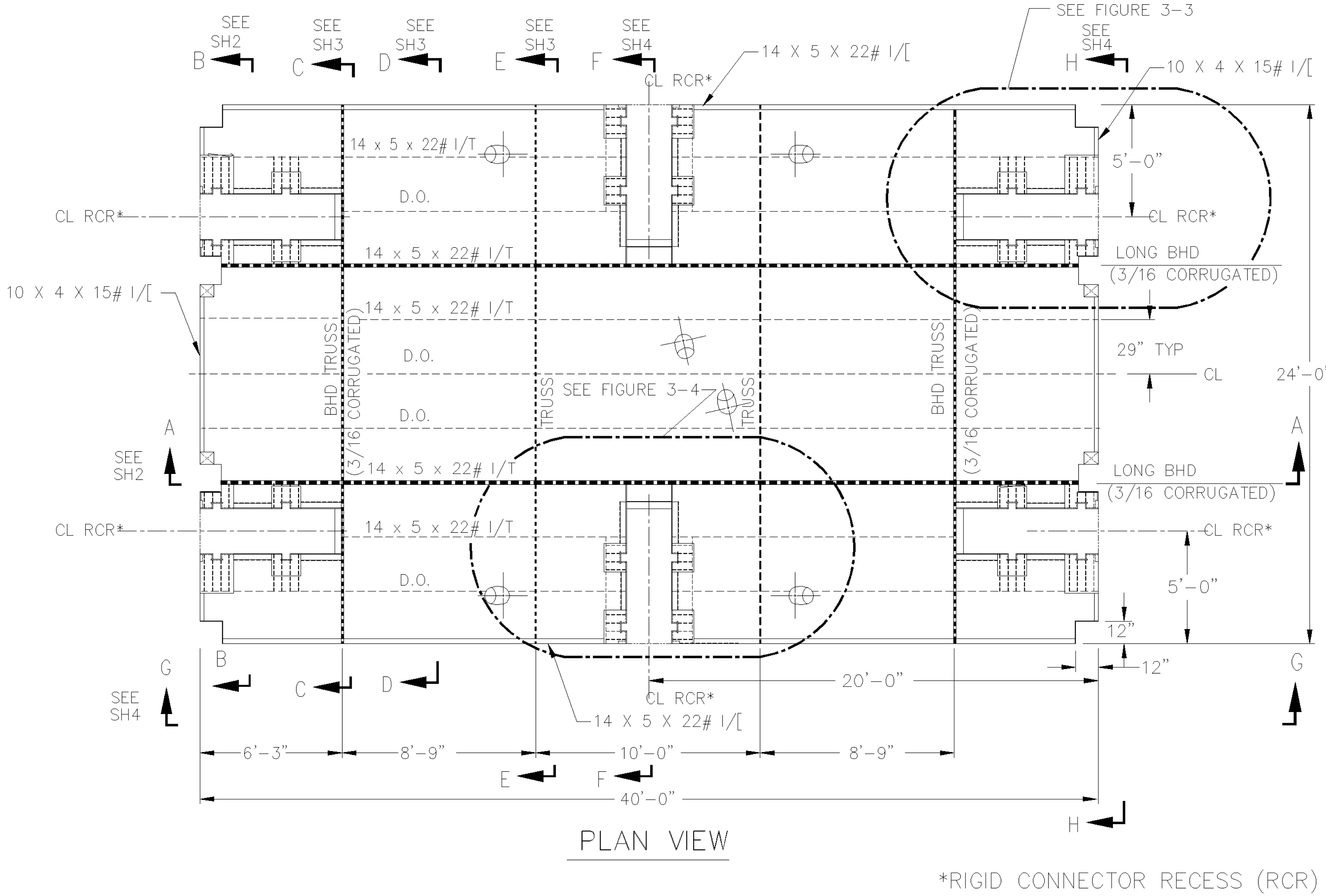


Figure 3-1. ACB Lighter Center Module Scantling Arrangement and Details (Sheet 1 of 4)

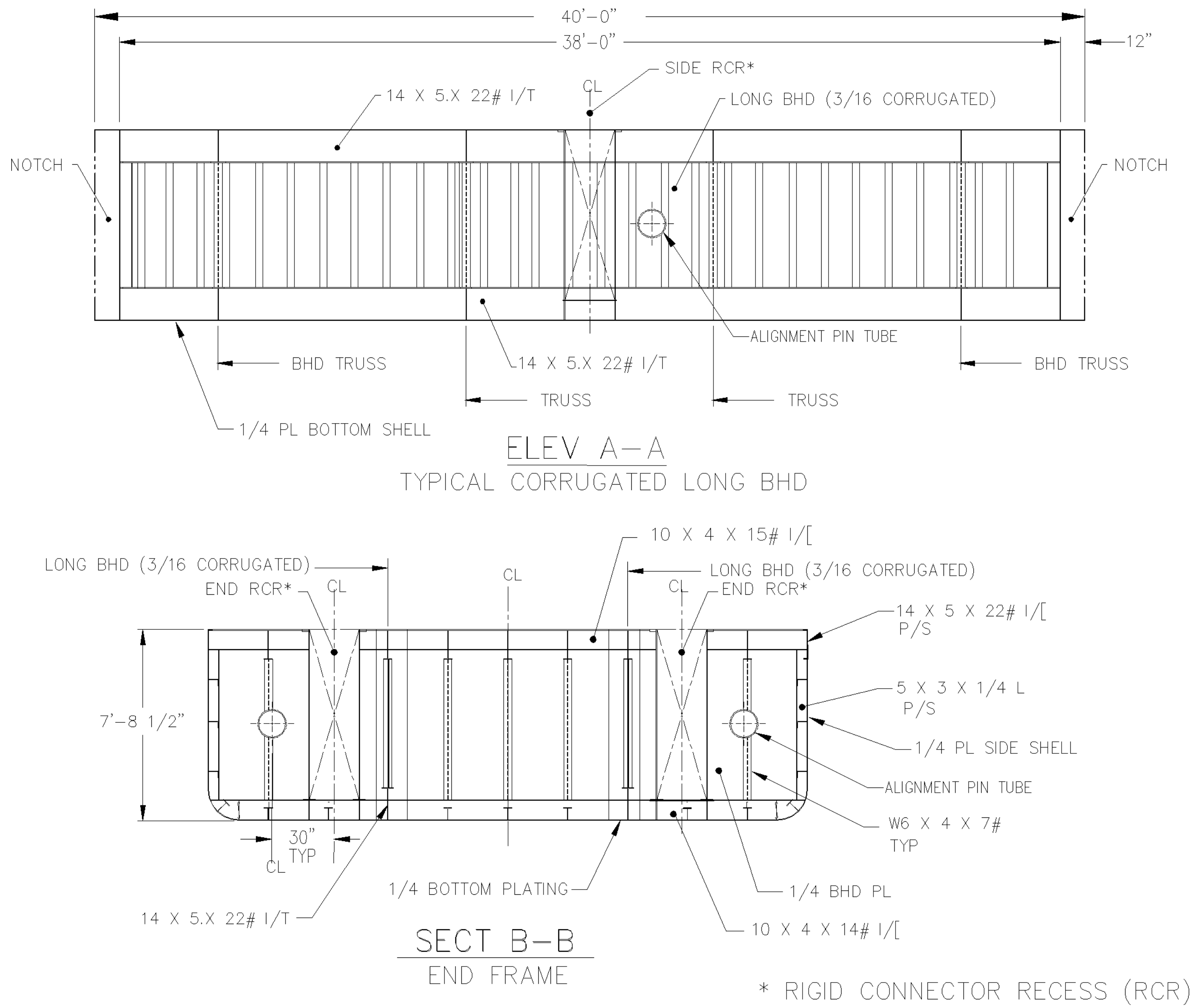
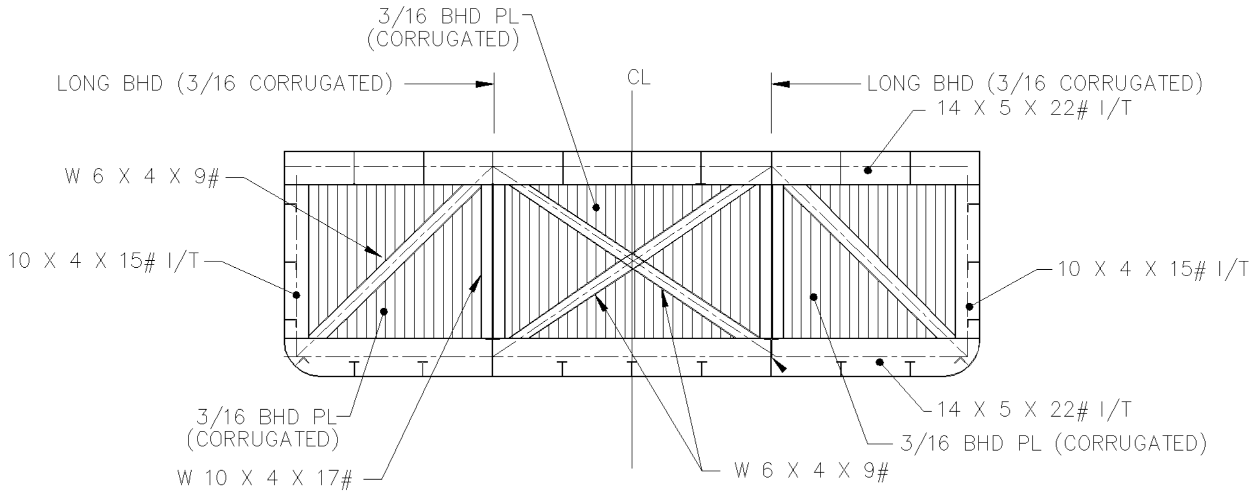
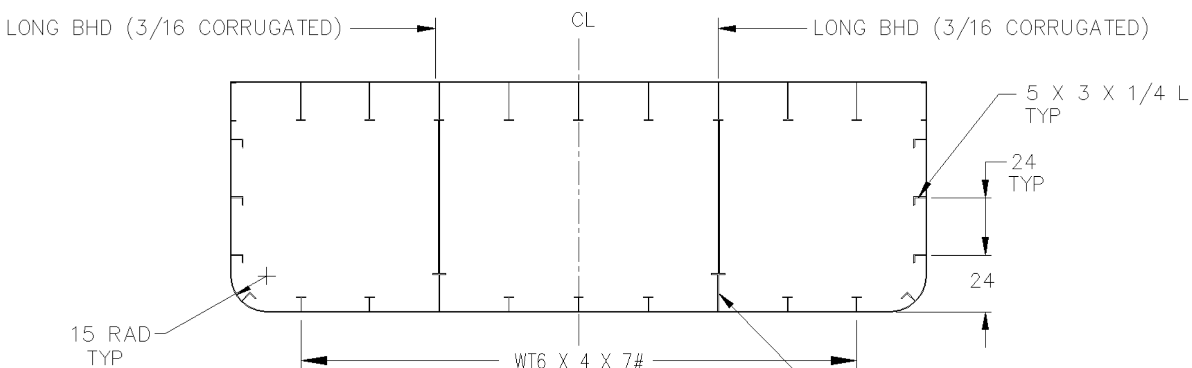


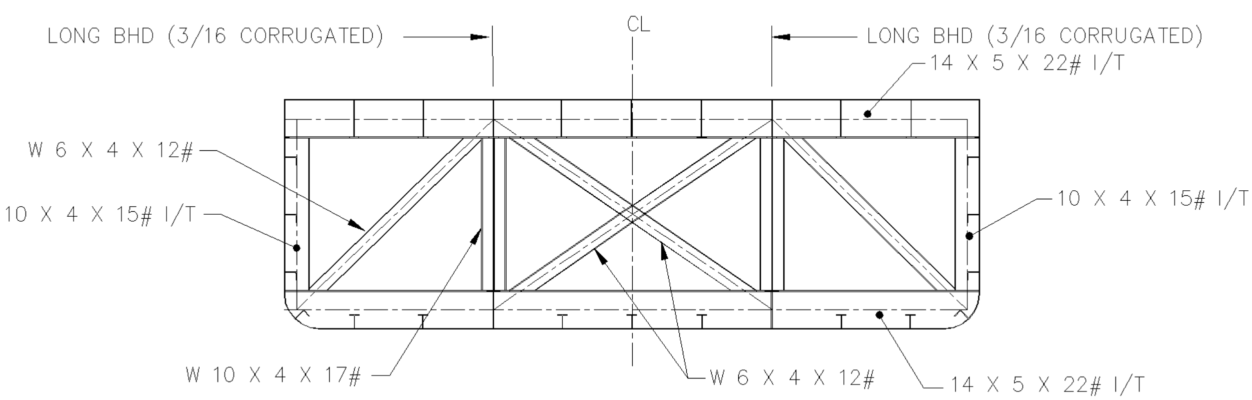
Figure 3-1
Sh. 2 of 4



SECT C–C
TYPICAL BHD TRUSS

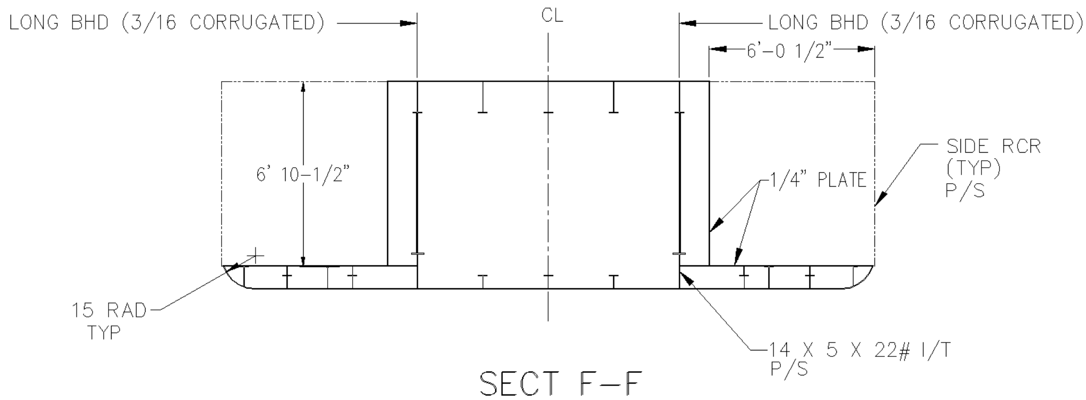


SECT D–D
TYPICAL CROSS SECTION



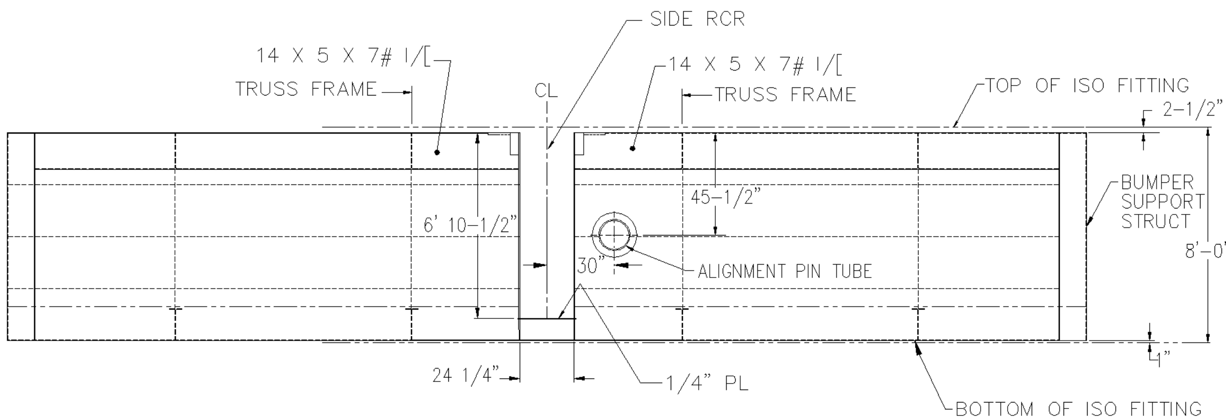
SECT E–E
TYPICAL TRUSS

Figure 3-1
Sh. 3 of 4

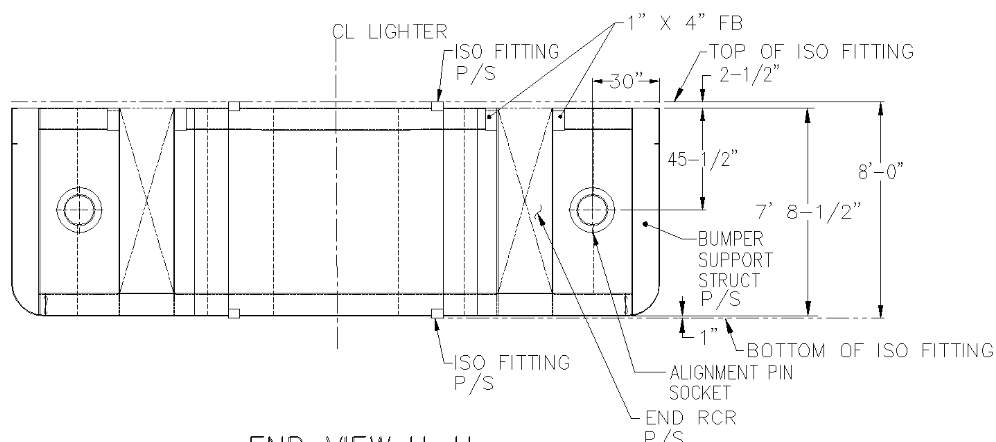


SECT F-F

CROSS SECTION THRU SIDE RIGID CONNECTOR RECESS (RCR)



SIDE VIEW G-G



END VIEW H-H

Figure 3-1
Sh. 4 of 4

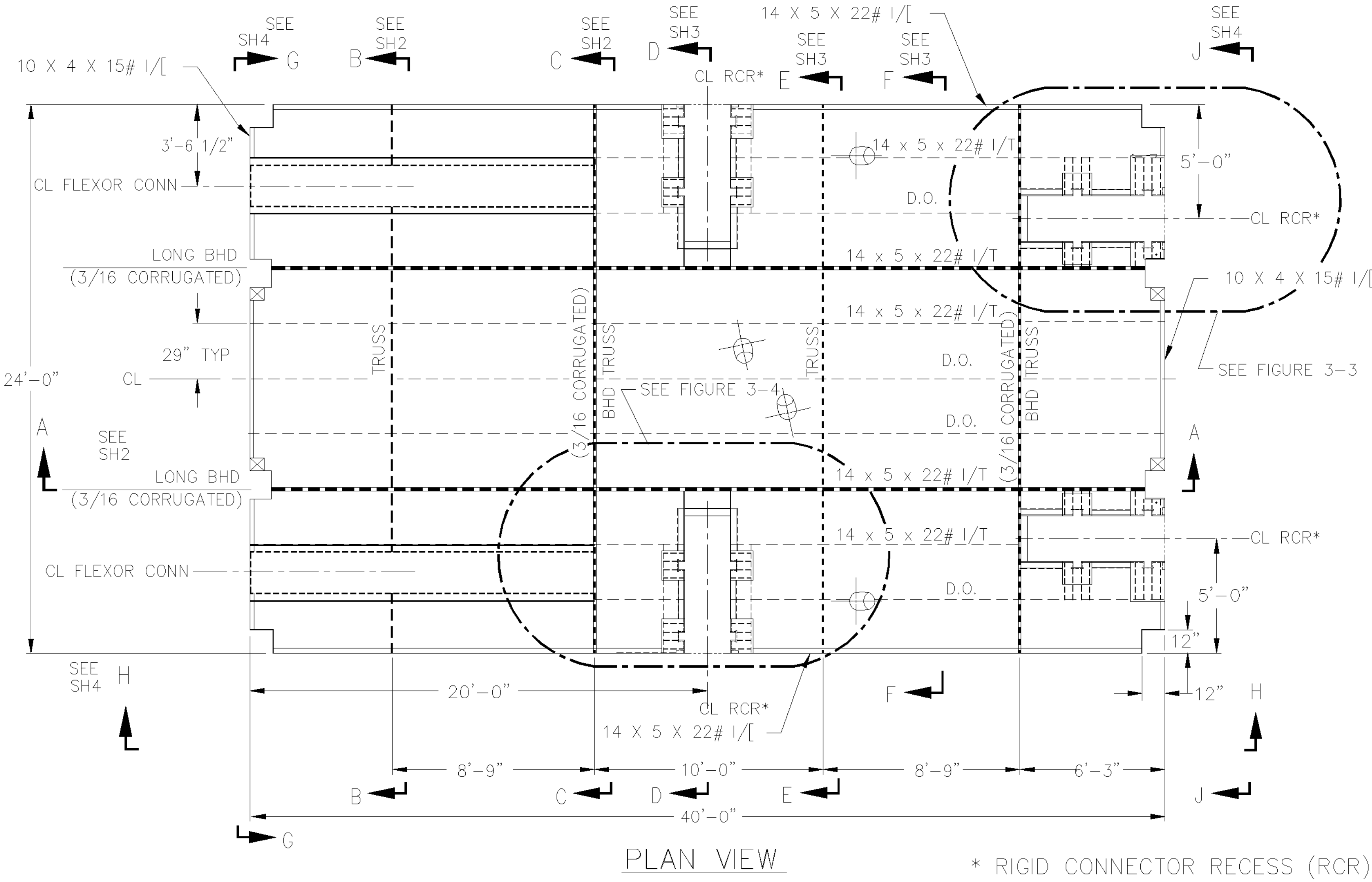


Figure 3-2. ACB Lighter Raked Module Scantling Arrangement and Details (Sheet 1 of 4)

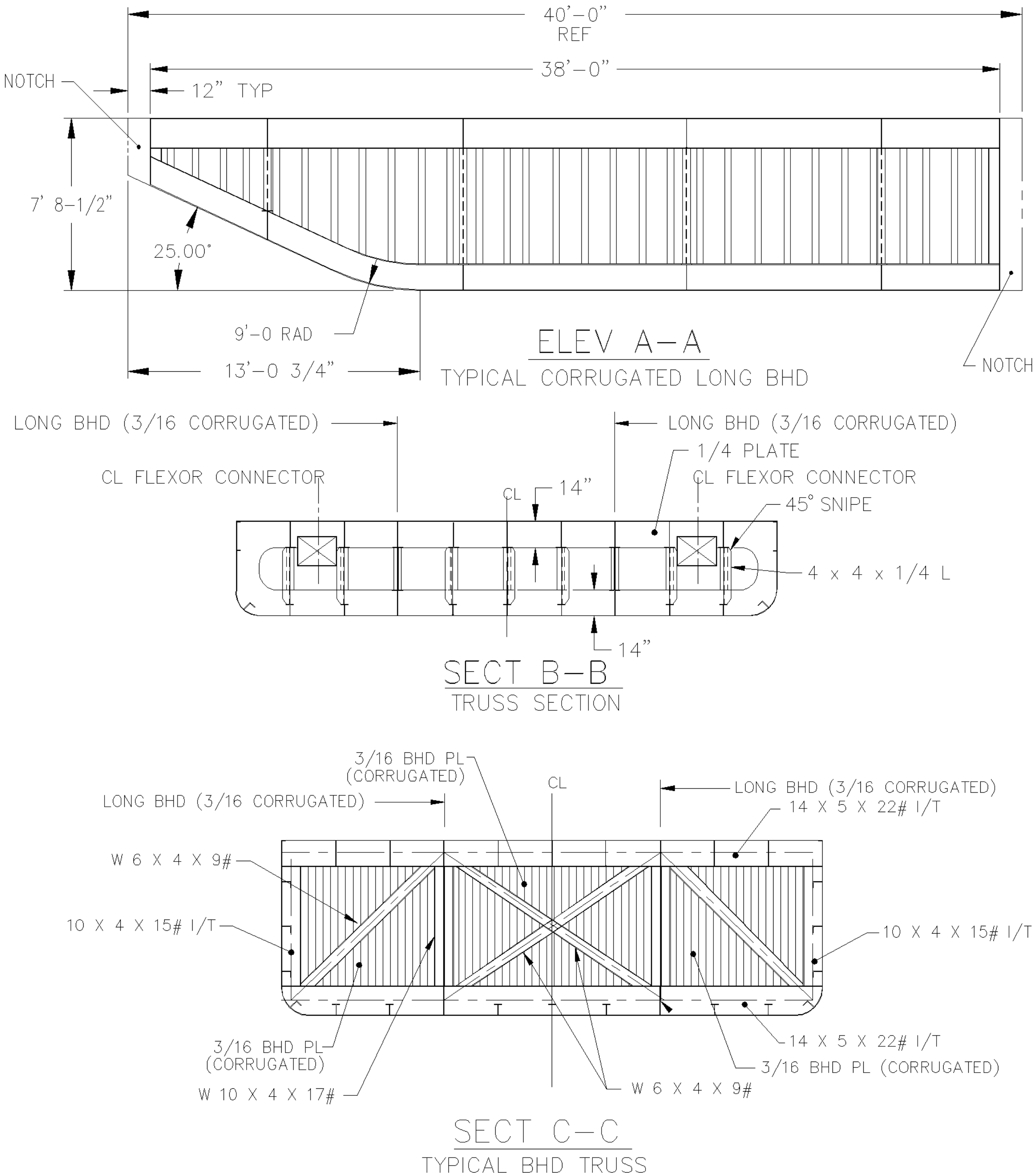
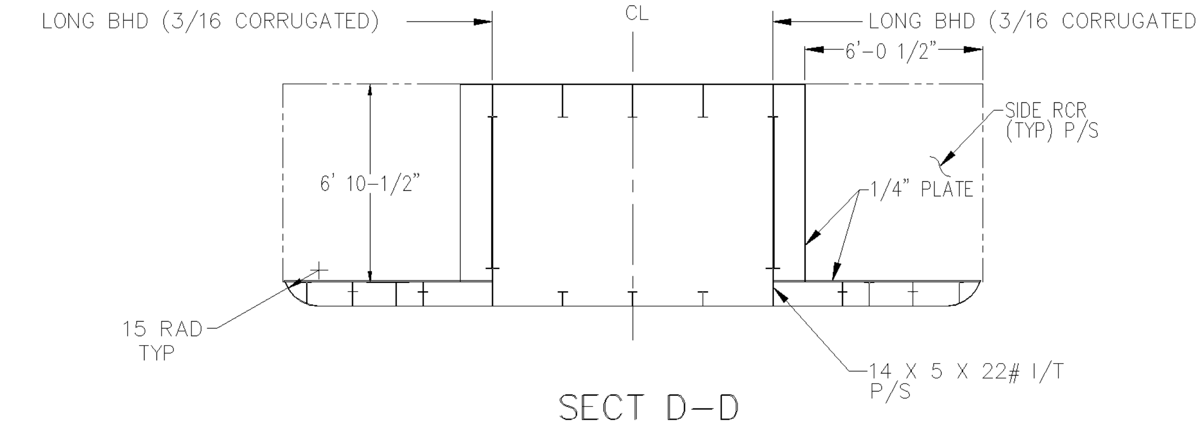
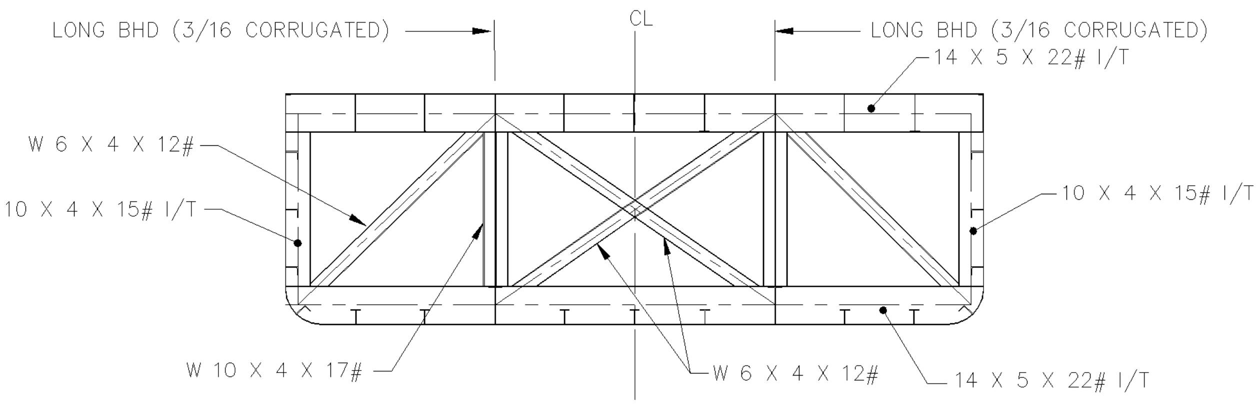


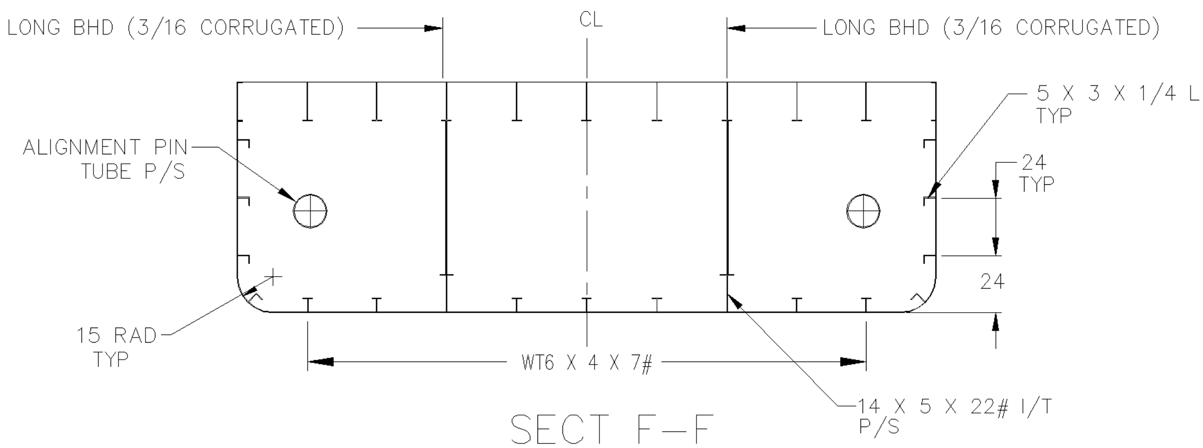
Figure 3-2
Sh. 2 of 4



SECT D-D
CROSS SECTION THRU SIDE RIGID CONNECTOR RECESS (RCR)

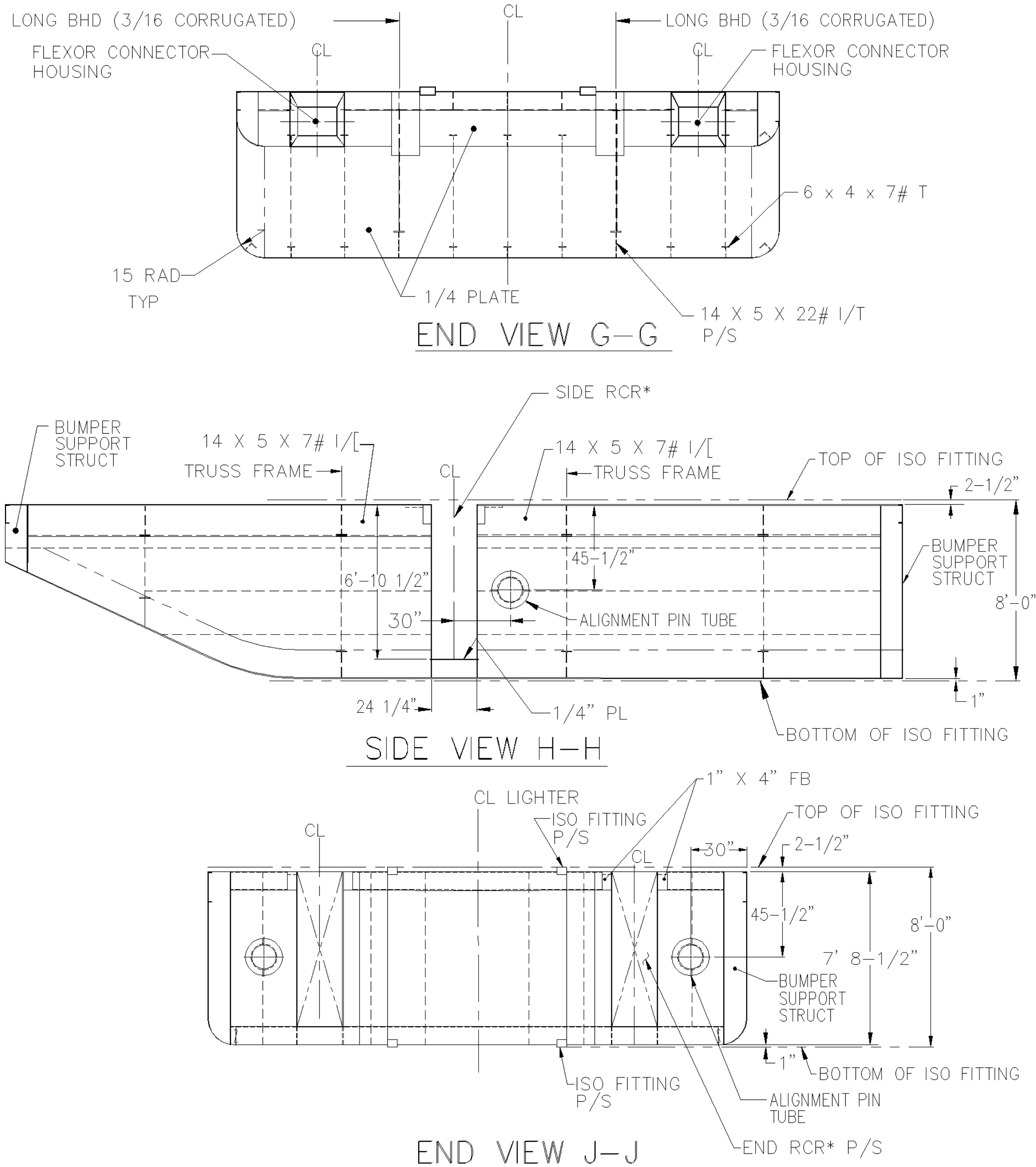


SECT E-E
TYPICAL TRUSS



SECT F-F
TYPICAL CROSS SECTION

Figure 3-2
Sh. 3 of 4



* RIGID CONNECTION RECESS (RCR)

Figure 3-2
Sh. 4 of 4

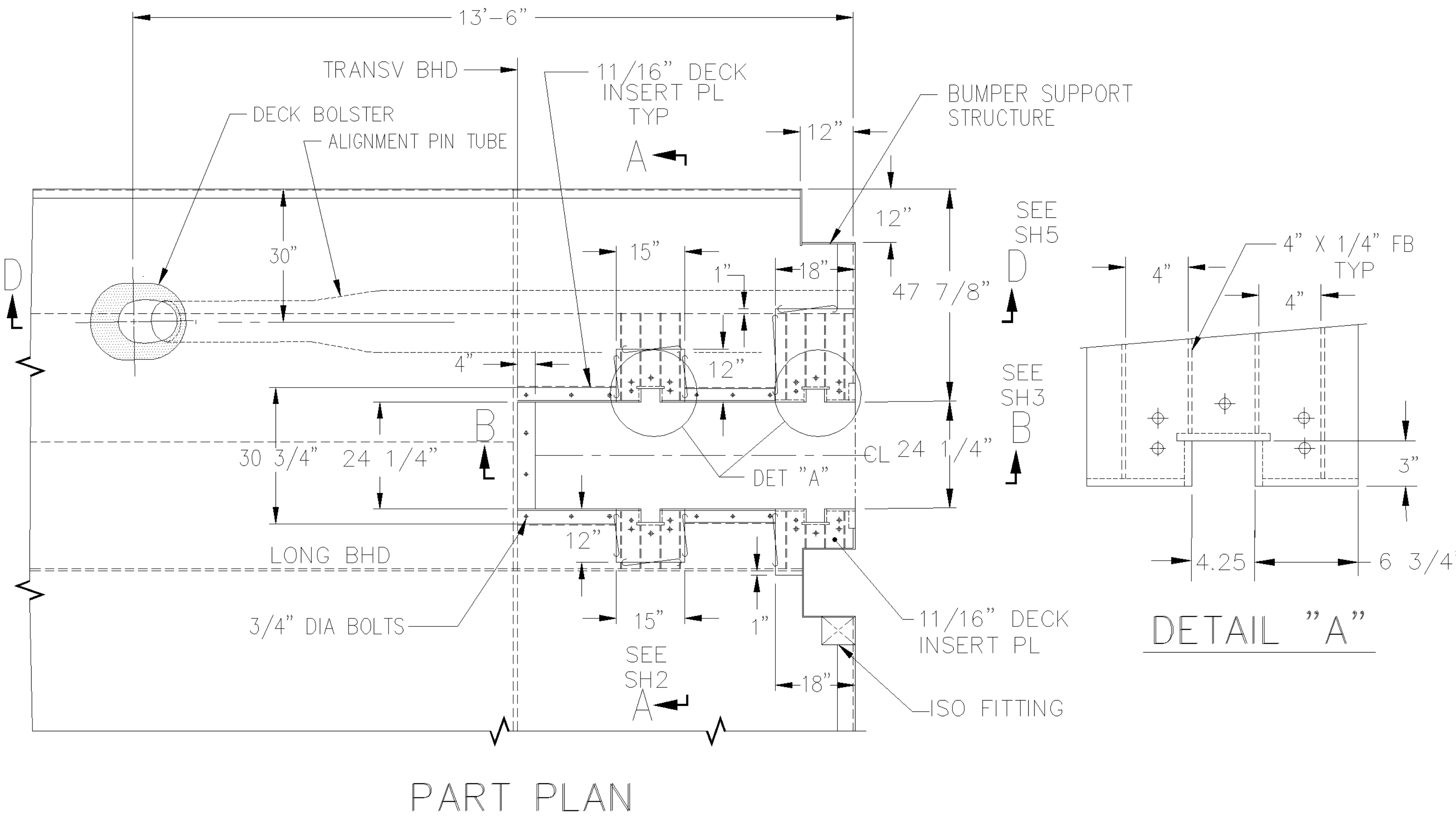


Figure 3-3. Typical Rigid Connector Recess (RCR) at ACB Module End (Sheet 1 of 5)

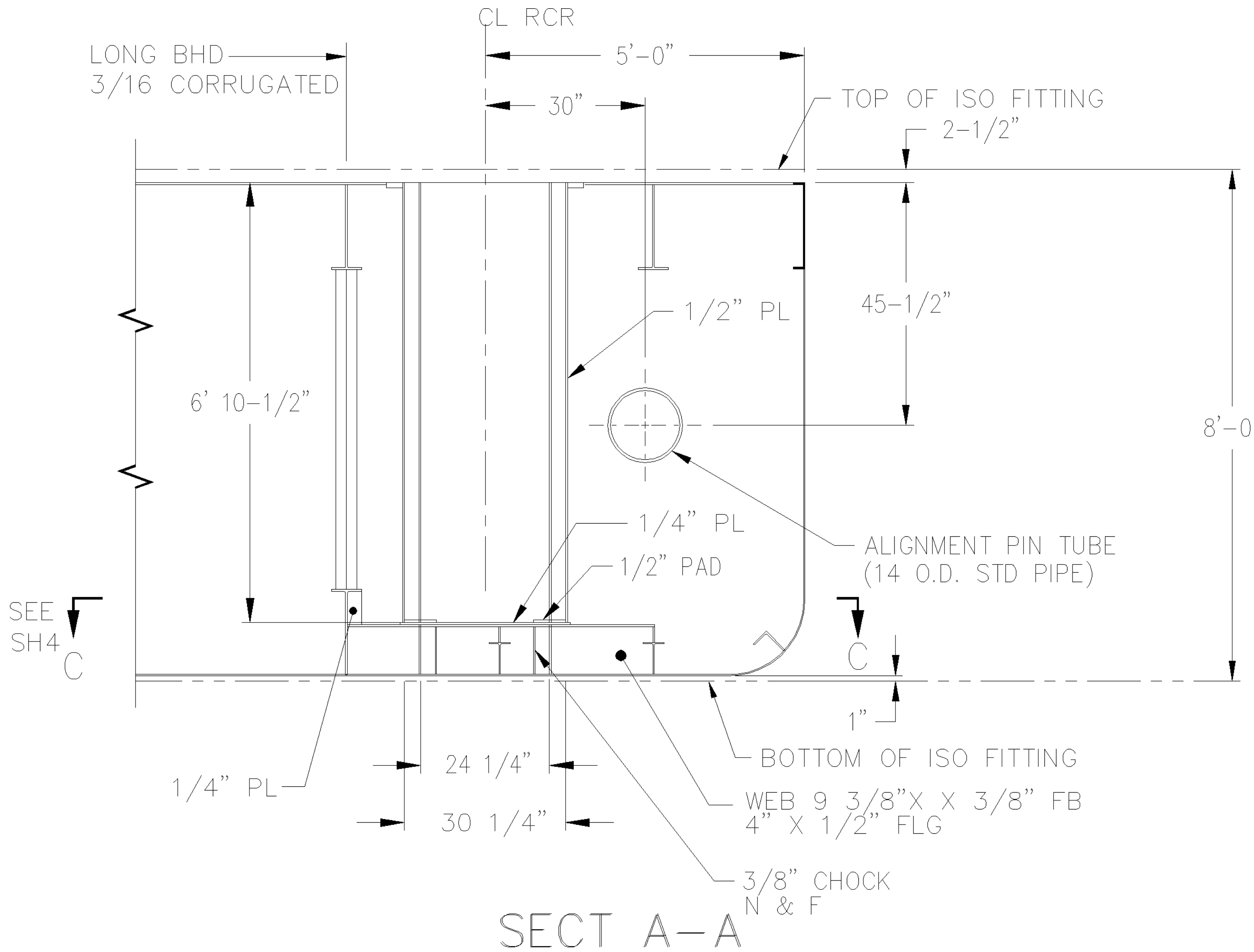
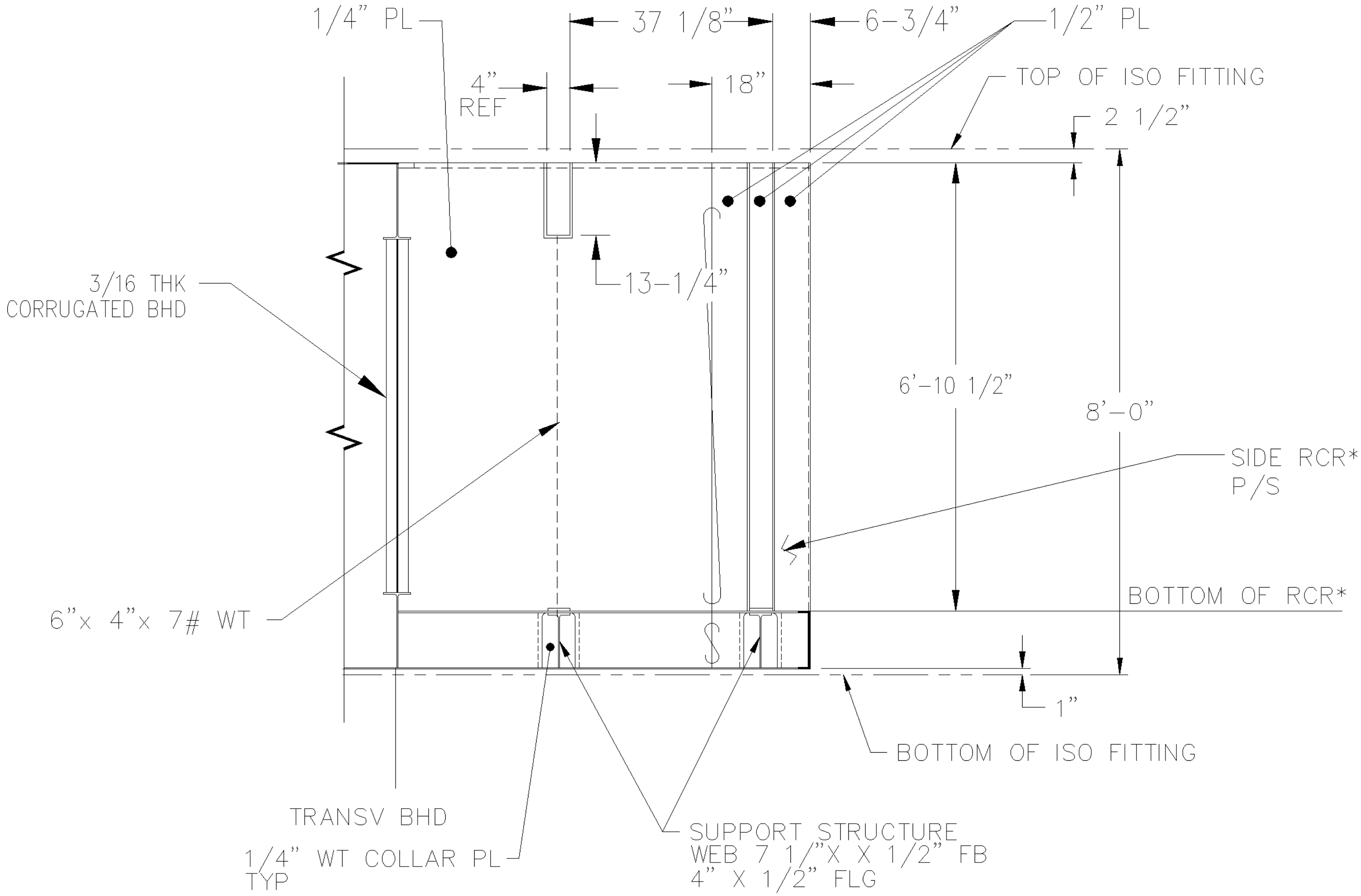


Figure 3-3
Sh. 2 of 5



SECT B-B

* RIGID CONNECTOR RECESS (RCR)

Figure 3-3
Sh. 3 of 5

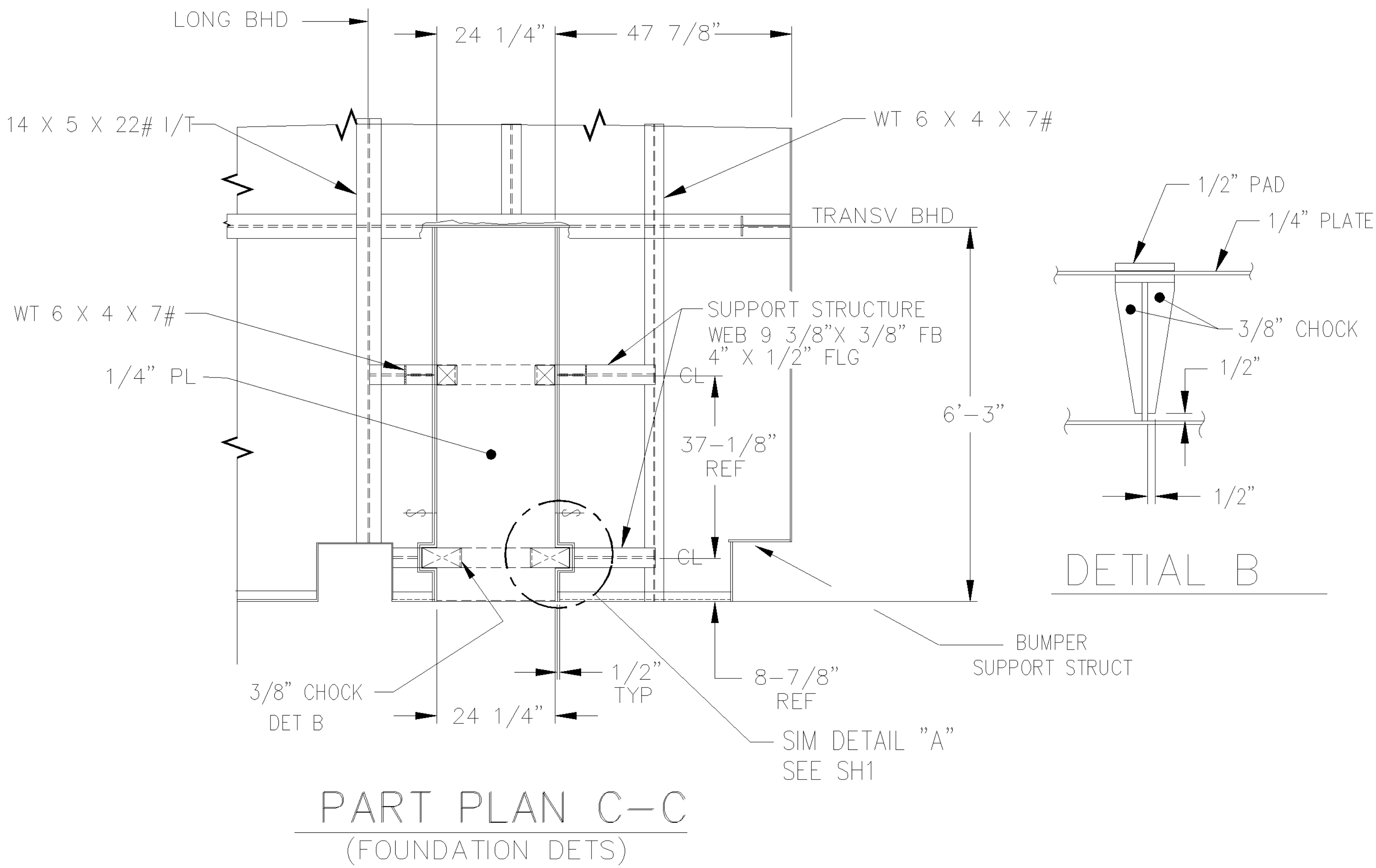
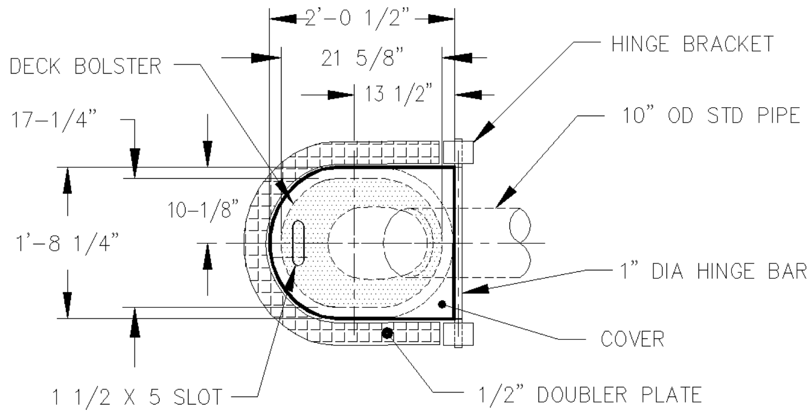
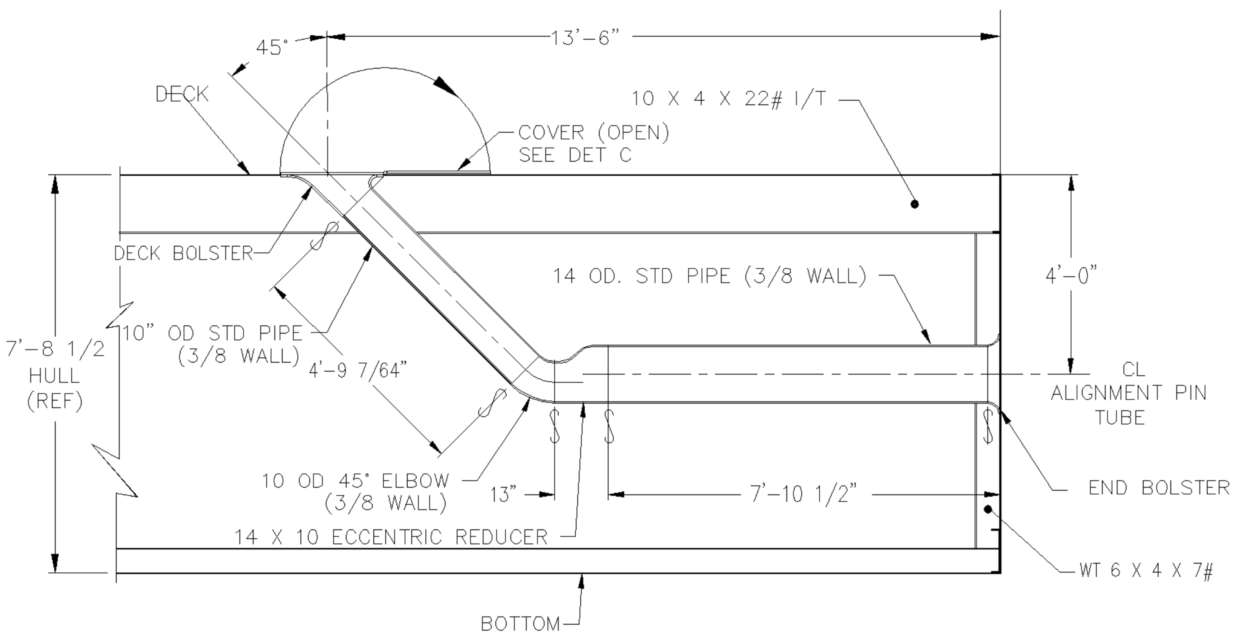


Figure 3-3
Sh. 4 of 5



DETAIL "C"
HINGED COVER PL TYPE A



SECT D-D
TYPICAL END ALIGNMENT PIN TUBE

Figure 3-3
Sh. 5 of 5

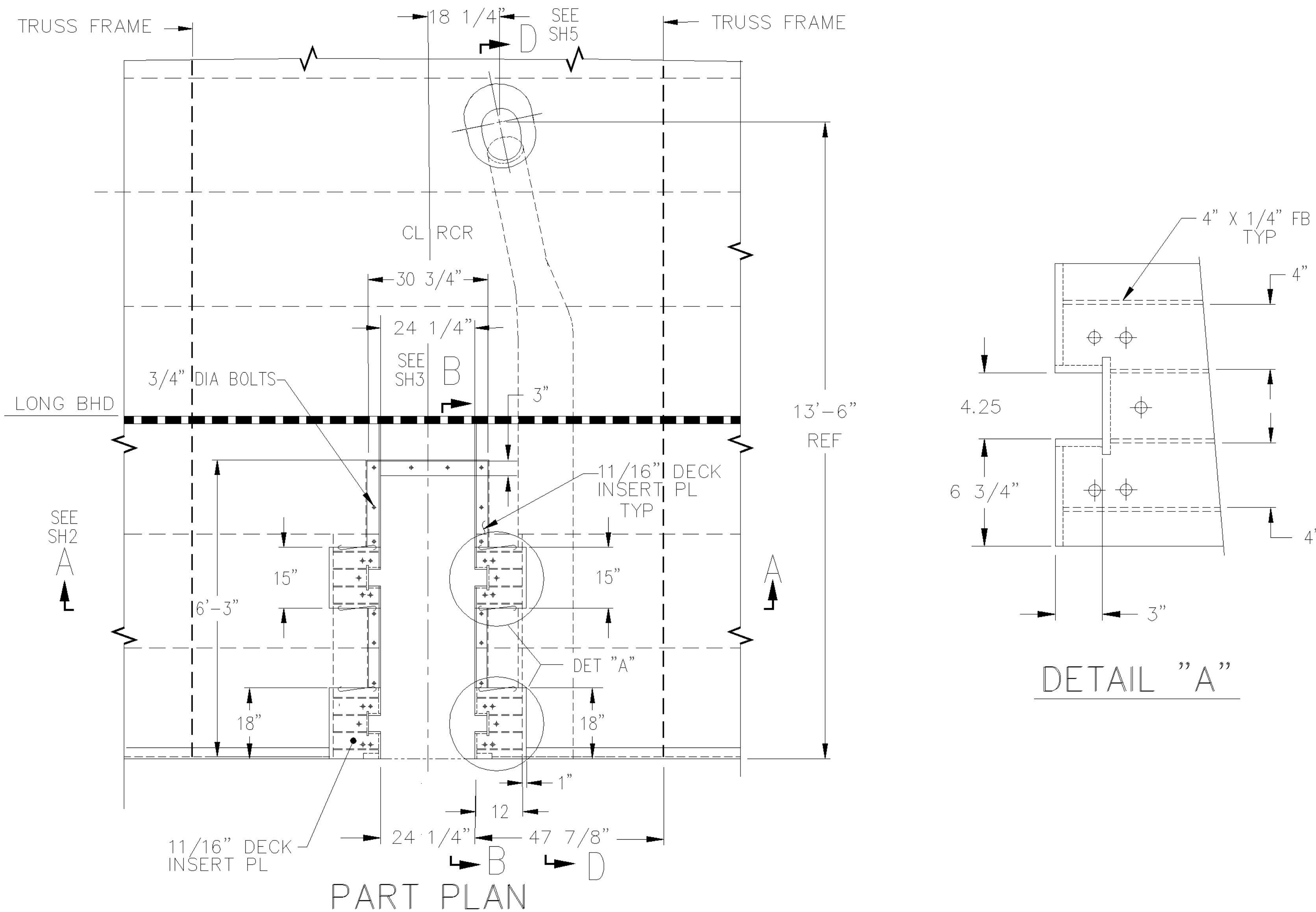


Figure 3-4. Typical Rigid Connector Recess (RCR) at ACB Module Side (Sheet 1 of 5)

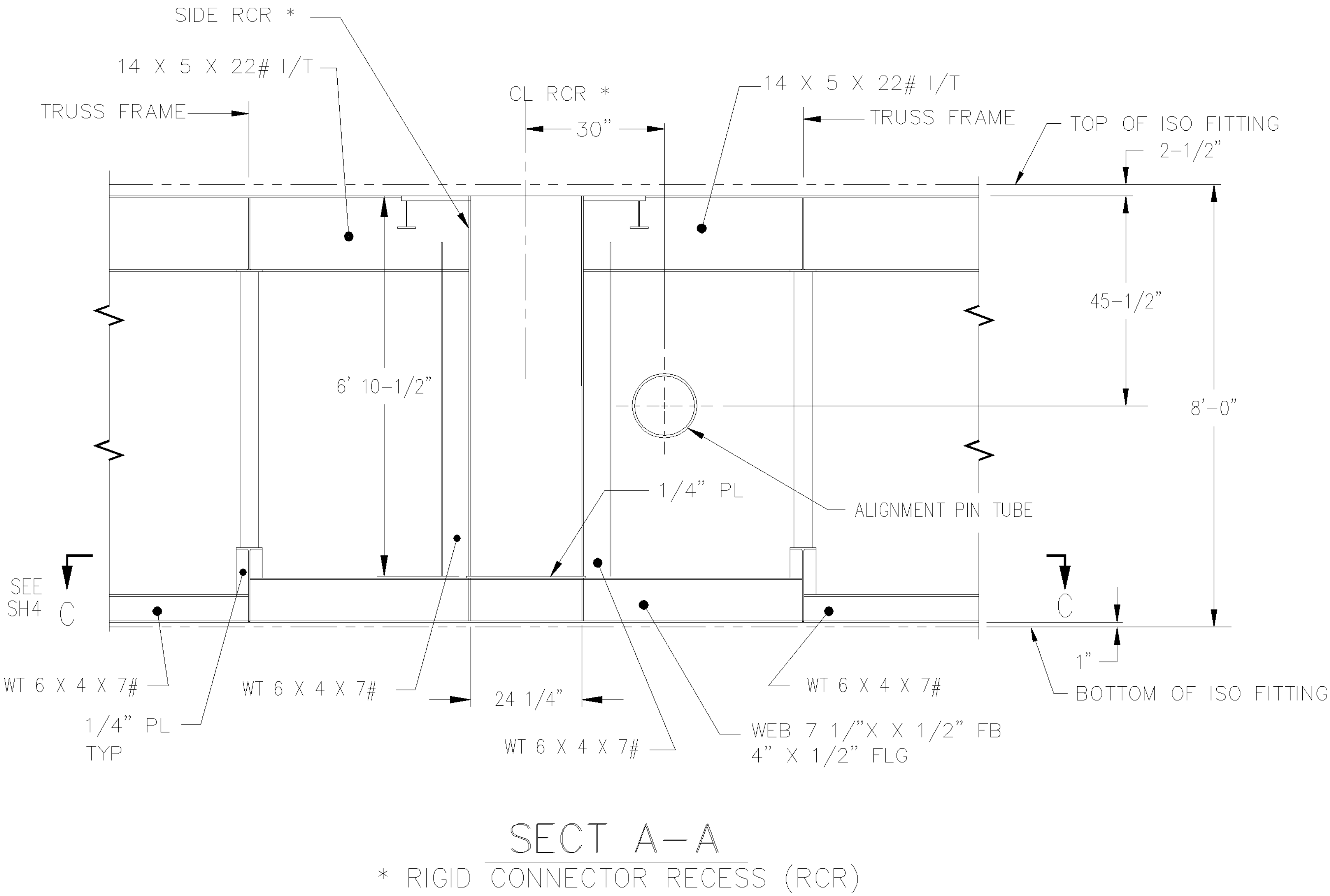
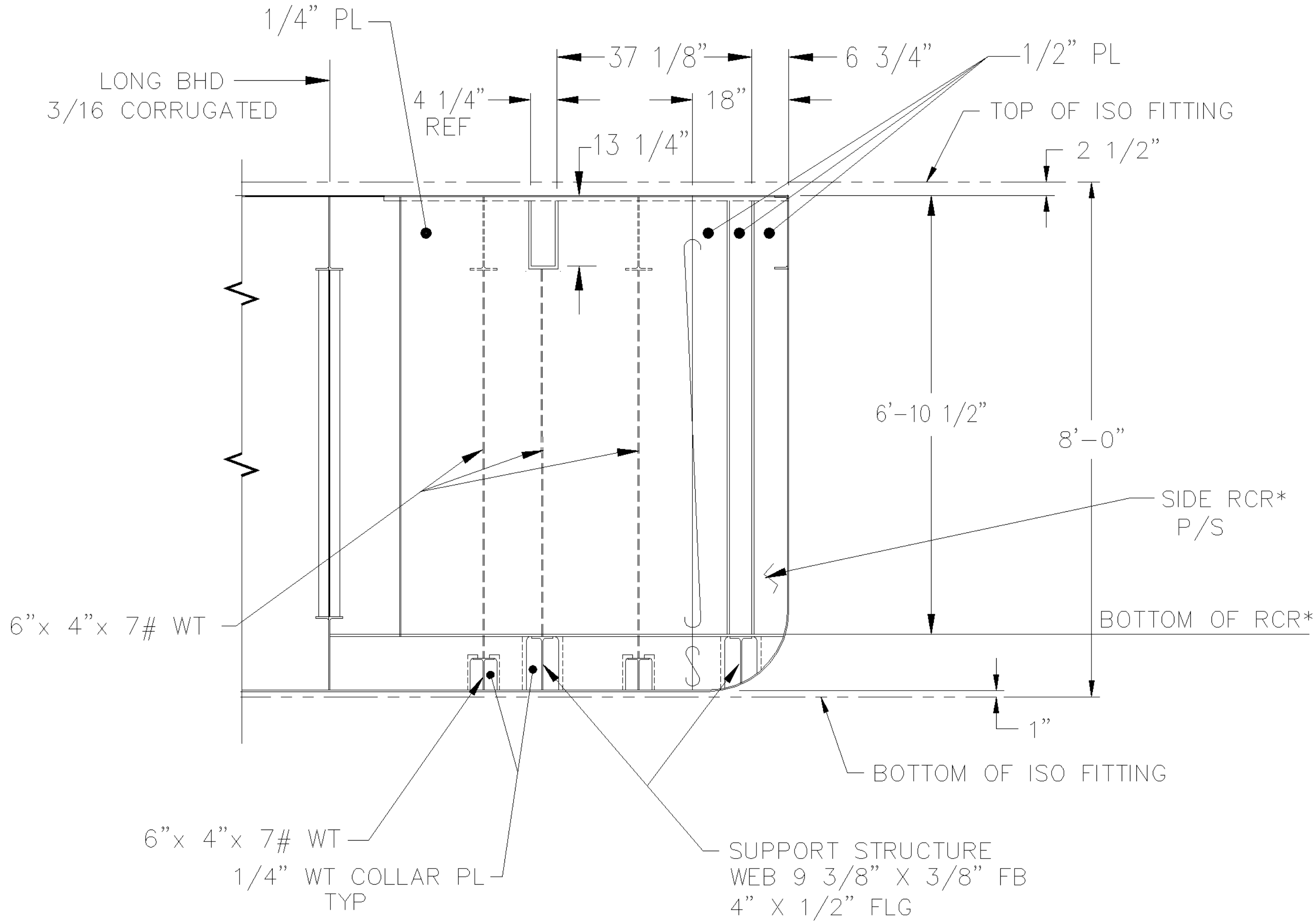


Figure 3-4
Sh. 2 of 5



SECT B–B

* RIGID CONNECTOR RECESS (RCR)

Figure 3-4
Sh. 3 of 5

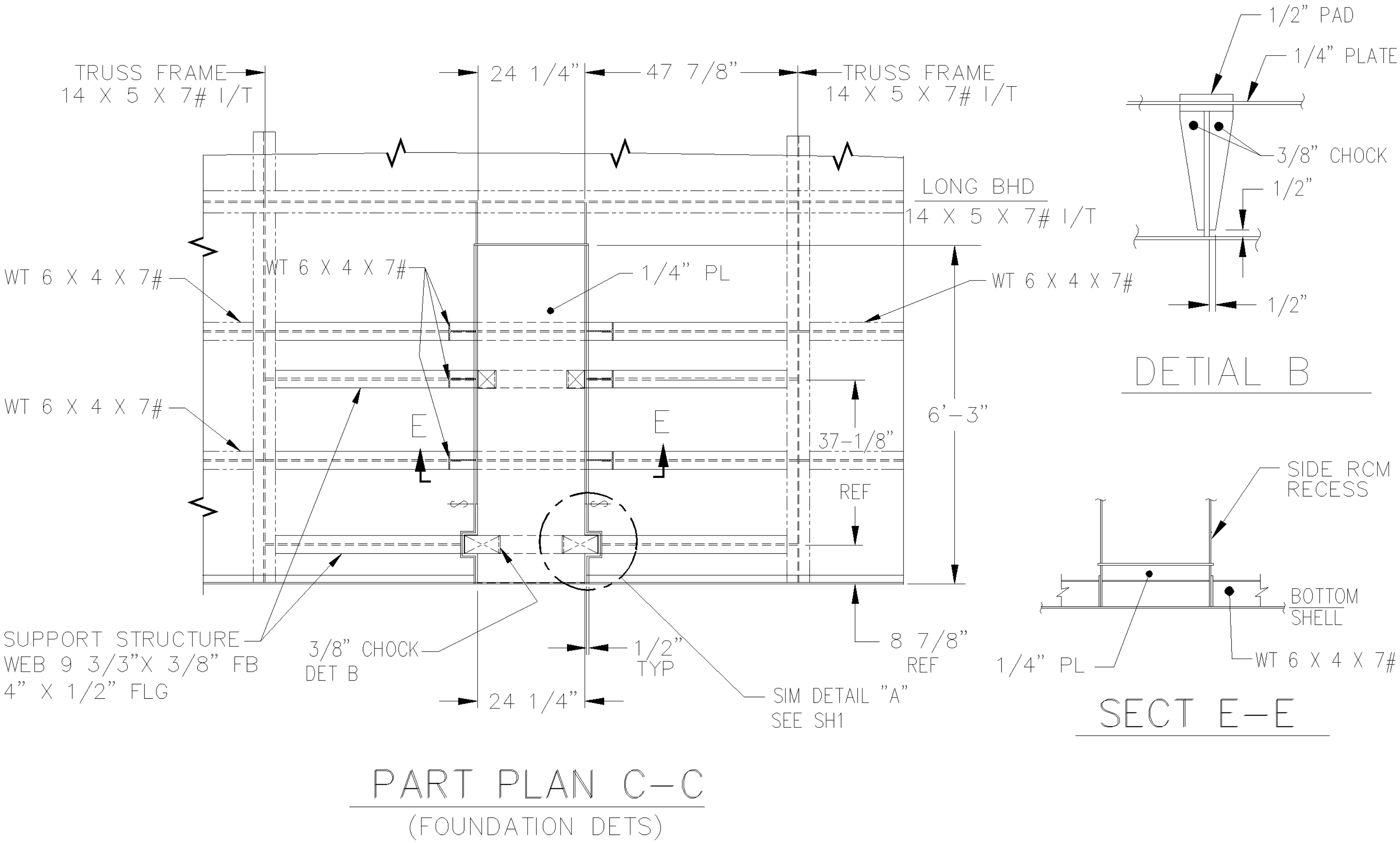
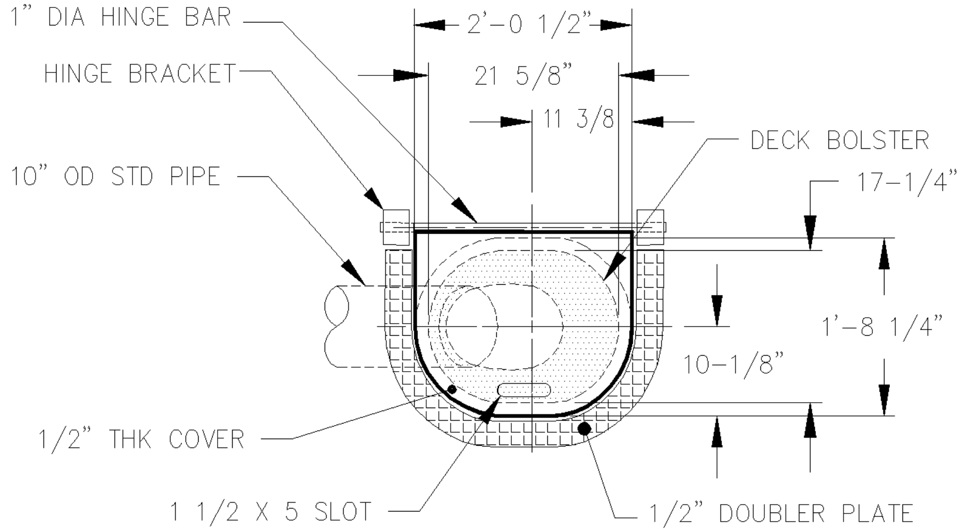
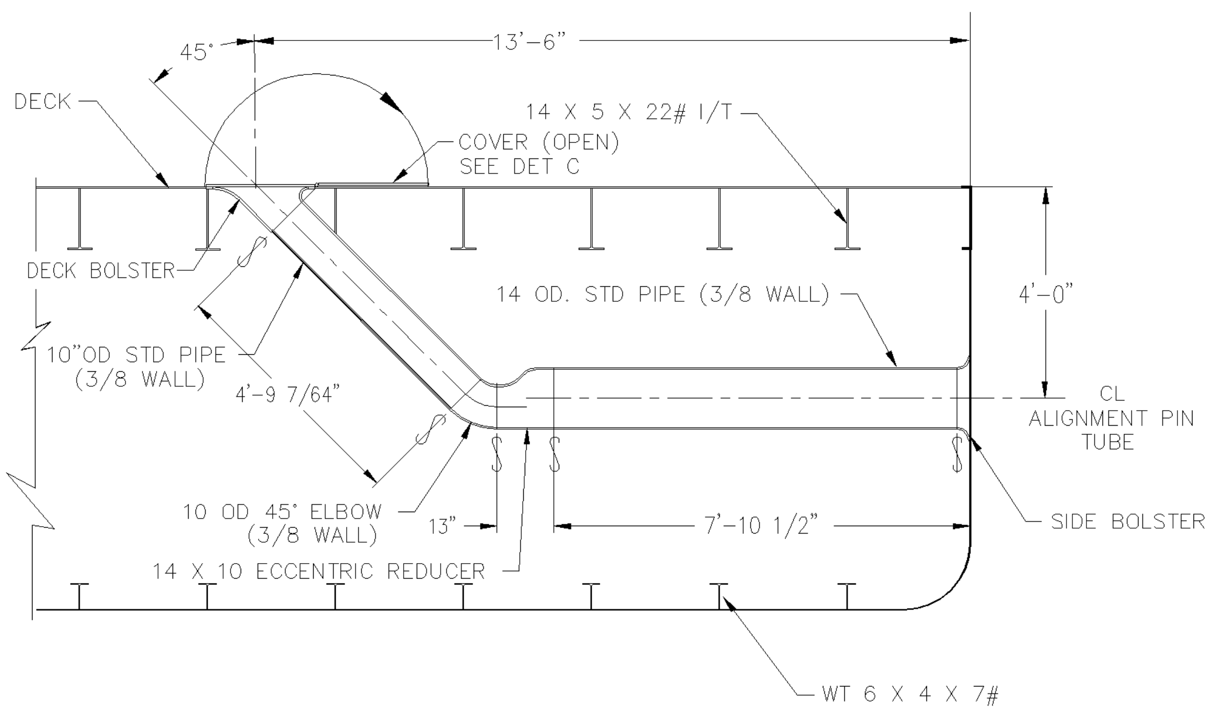


Figure 3-4
Sh. 4 of 5



DETAIL "C"

HINGED COVER PL TYPE B



SECT D-D

TYPICAL SIDE ALIGNMENT PIN TUBE

Figure 3-4
Sh. 5 of 5

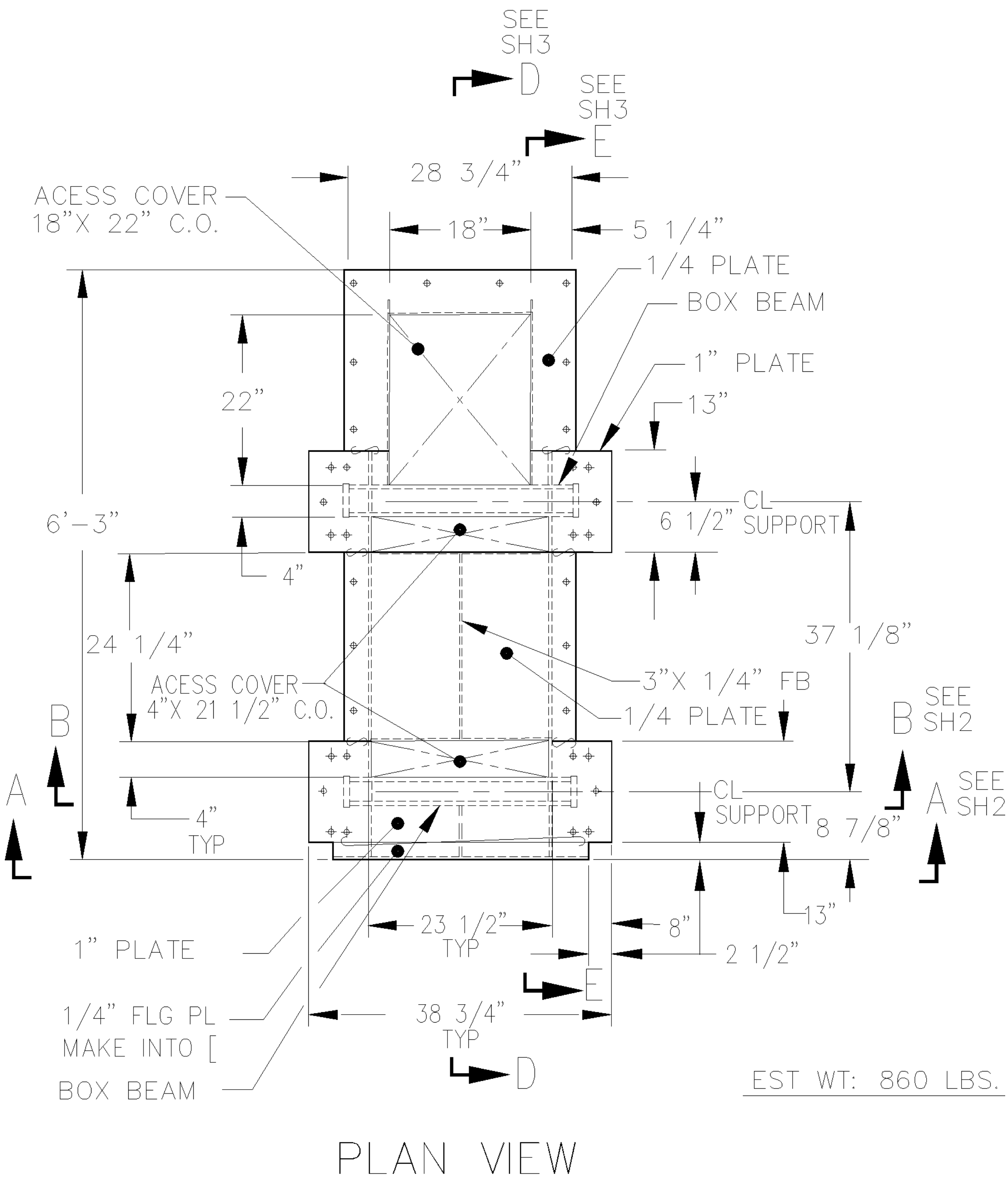


Figure 3-5. RCR Cover Weldment (Sheet 1 of 3)

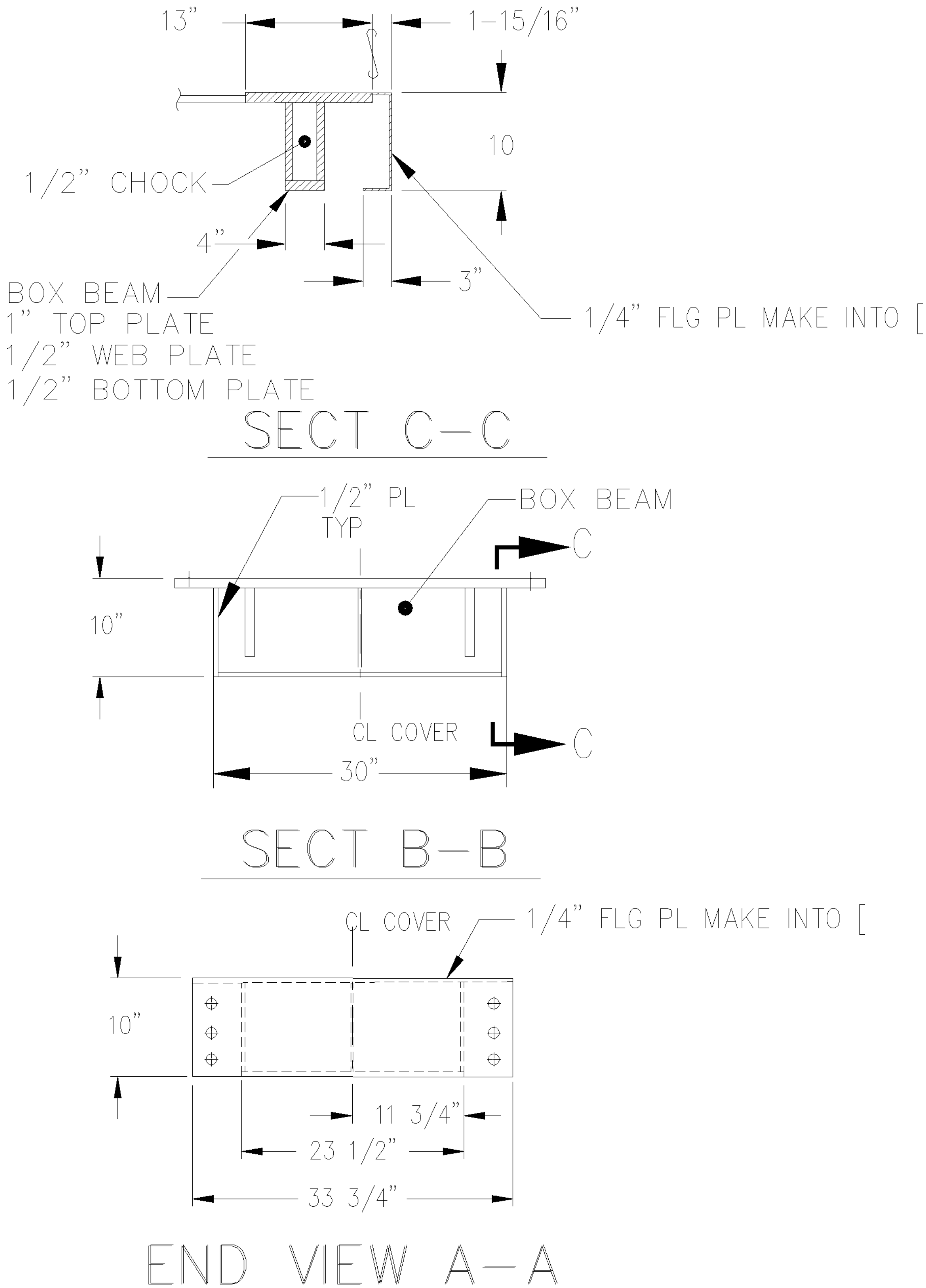


Figure 3-5
Sh. 2 of 3

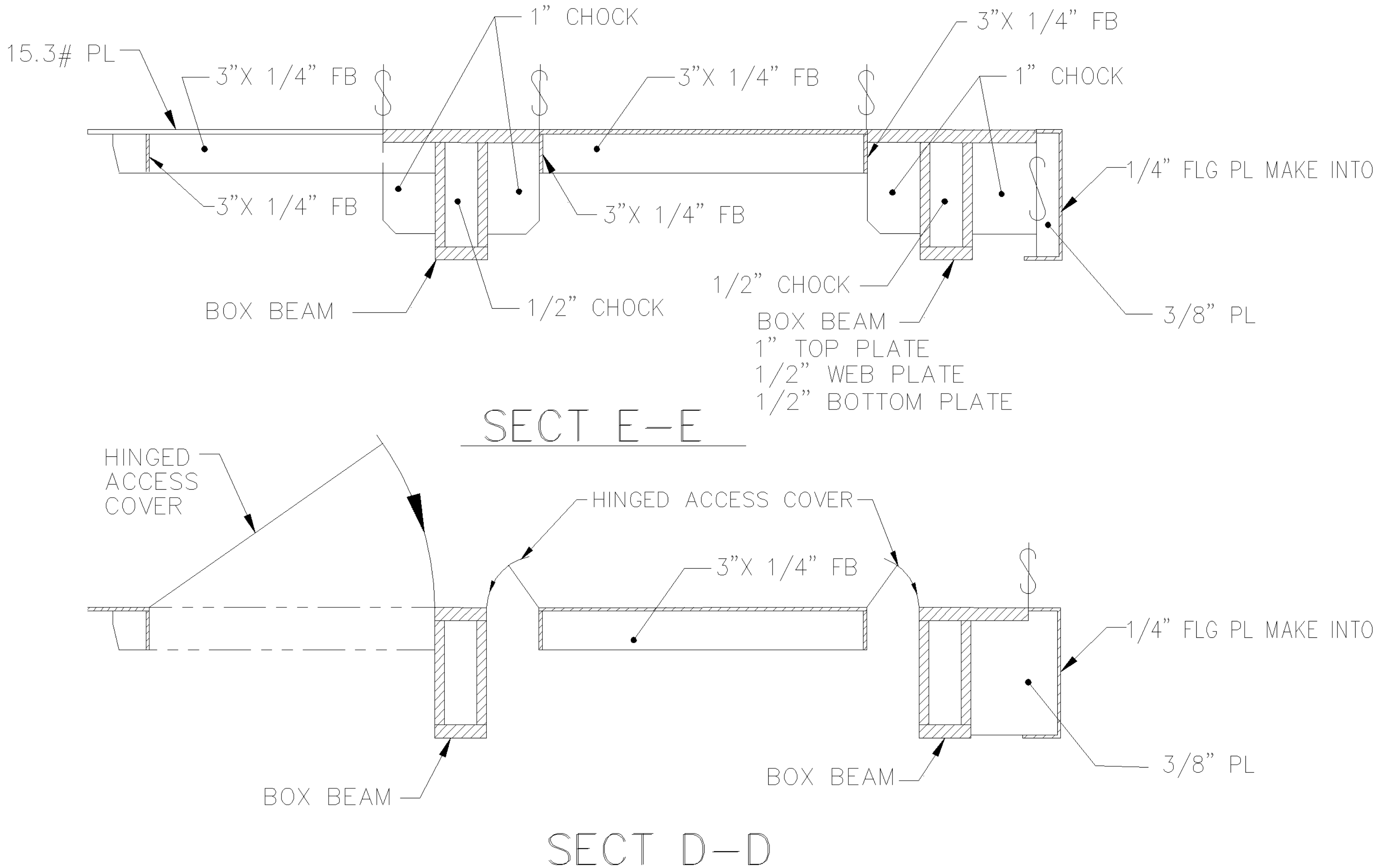


Figure 3-5
Sh. 3 of 3

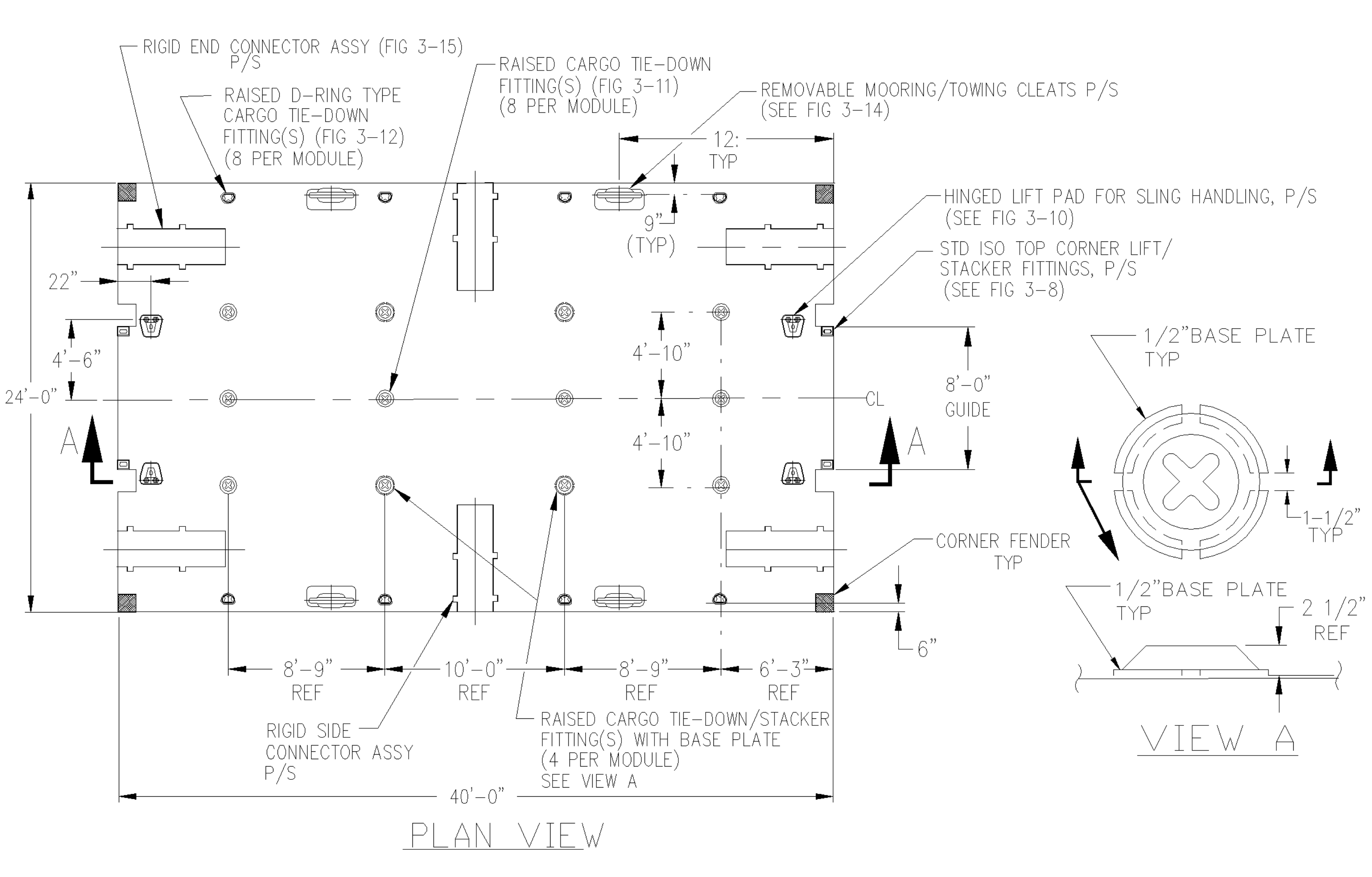
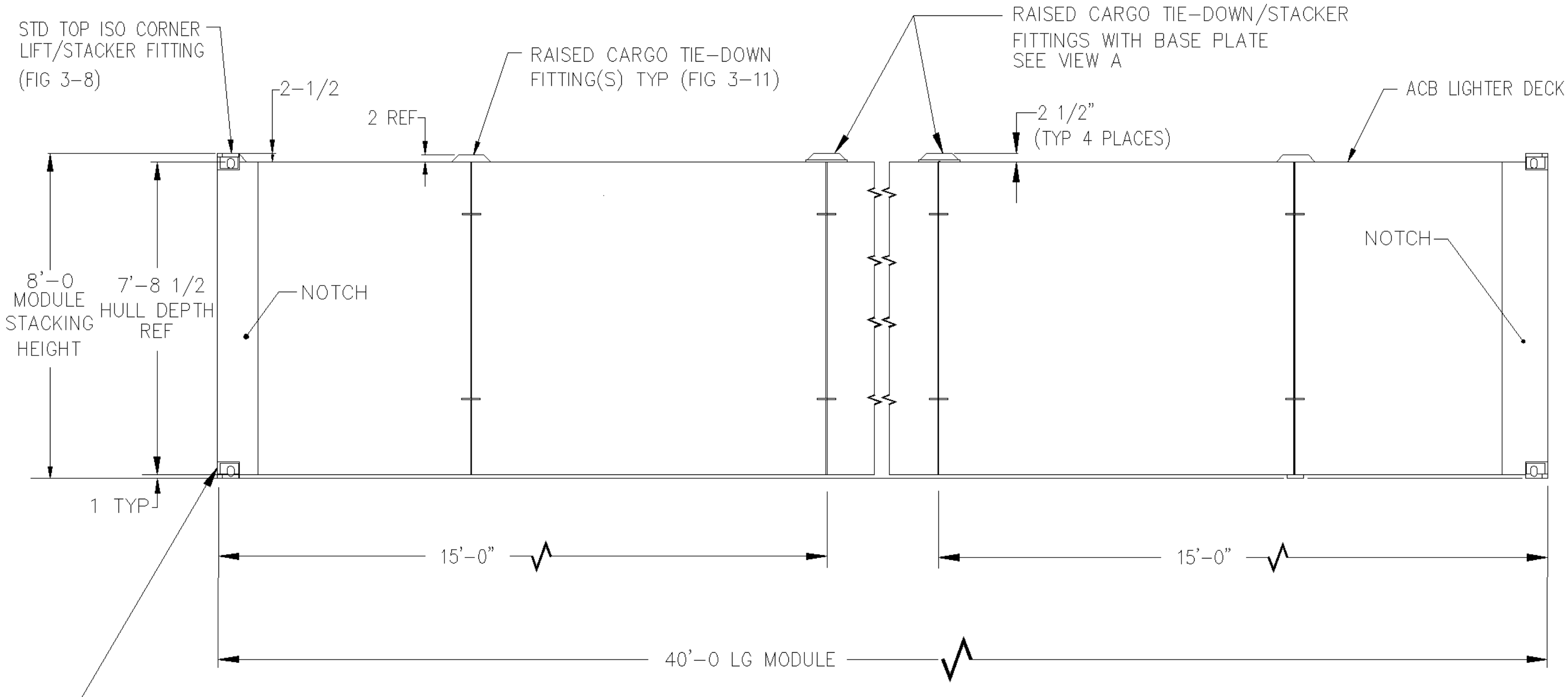


Figure 3-6. ACB Lighter Center Module Deck Fitting Arrangement and Details (Sheet 1 of 2)



SECTION A-A

Figure 3-6
Sh. 2 of 2

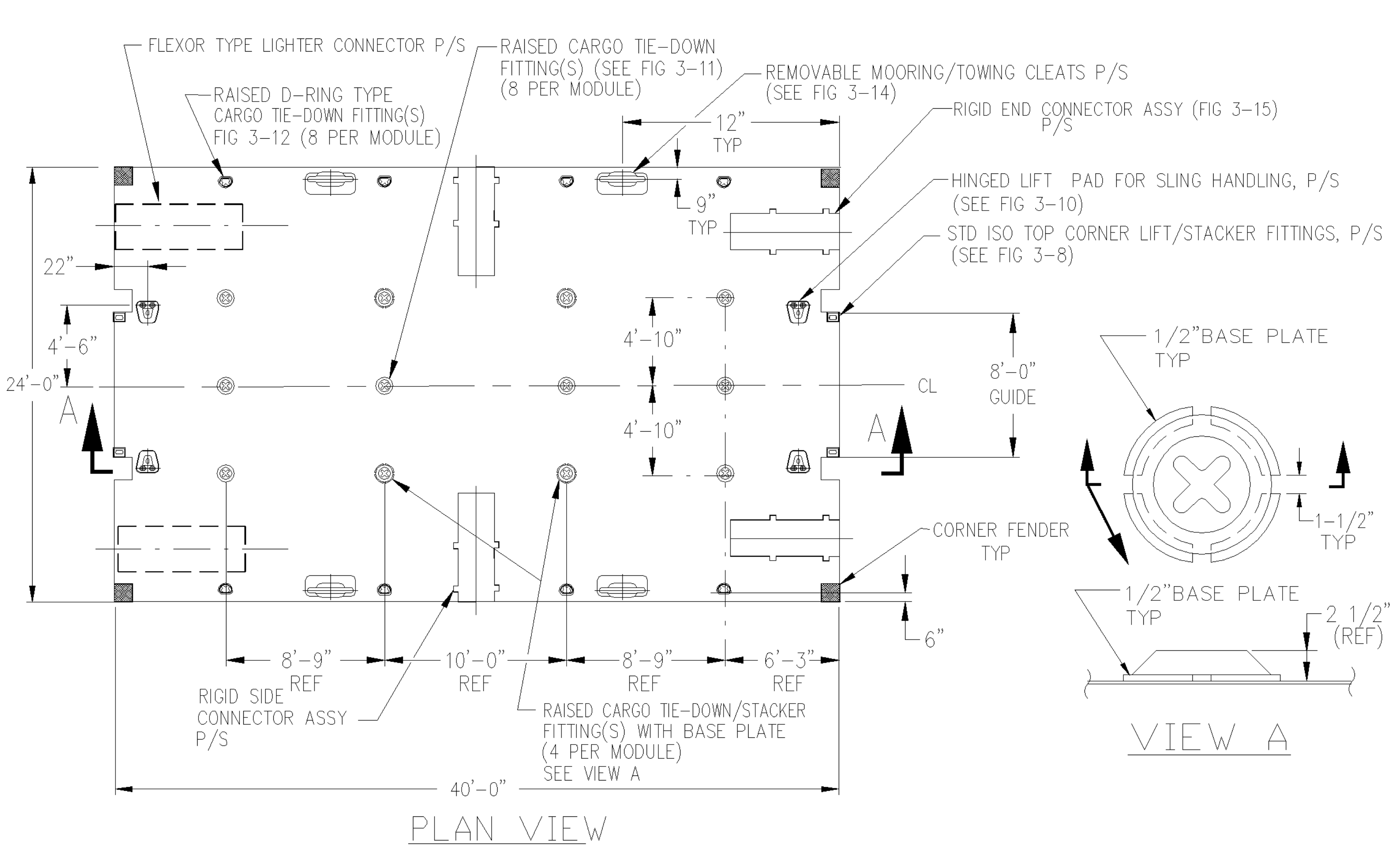


Figure 3-7. ACB Lighter Raked Module Deck Fitting Arrangement and Details (Sheet 1 of 2)

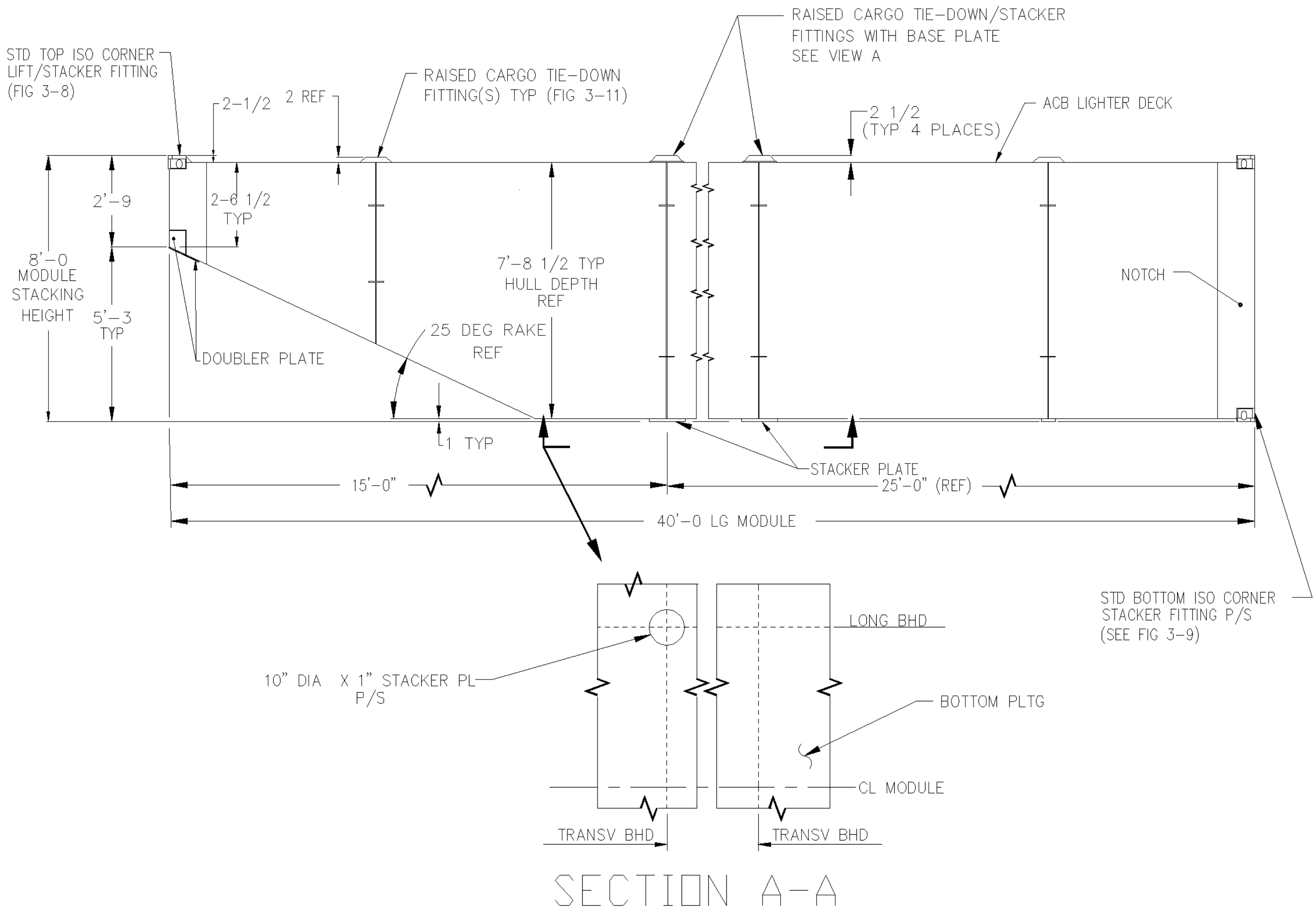
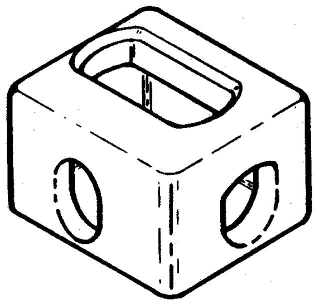


Figure 3-7
Sh. 2 of 2

NEXT ASSEMBLY

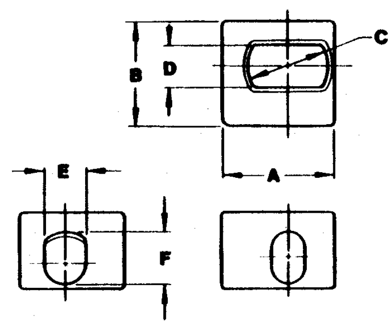
ISSUE	REVISION RECORD	DATE	APPD

F463
CORNER FITTING
(TOP I.S.O. CORNER FITTING)



DIMENSIONAL DATA

COMMERCIAL TOLERANCE APPLIES



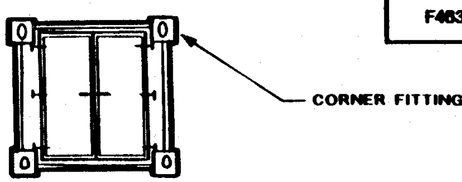
SPECIFICATIONS

MATERIAL:
CAST STEEL

STRENGTH:
MEETS STRENGTH REQUIREMENTS OF I.S.O. STANDARD 1161

FINISH:
SELF COLORED

MODEL NO.	DIM	A	B	C	D	E	F	WT KGS. (LBS.)
F463-1	MM	178.0	162.0	123.8	63.5	63.5	73.0	12.3
	(INCH)	(7.00)	(6.38)	(4.87)	(2.50)	(2.50)	(2.87)	(27.0)



APPLICATION

F463
CORNER FITTING
(TOP I.S.O. CORNER FITTING)

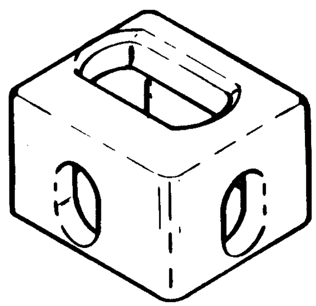
PECK & HALE, INC.
180 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

FSCM NO:94656	DRN: S.M.	SHEET OF	
DATE: 10/23/91	APPD: S.J.	2023 DWG NO	REV
SCALE: NONE	Q.C.:		

Figure 3-8. ISO Corner Fitting (Top)

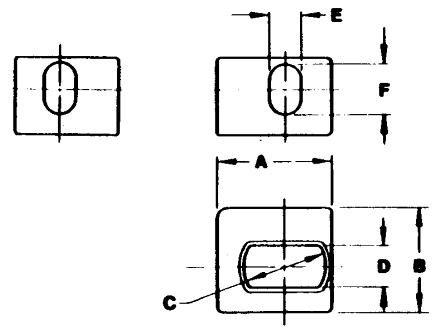
NEXT ASSEMBLY	ISSUE	REVISION RECORD	DATE	APPD

F463
CORNER FITTING
(BOTTOM I.S.O. CORNER FITTING)



DIMENSIONAL DATA

COMMERCIAL TOLERANCE APPLIES



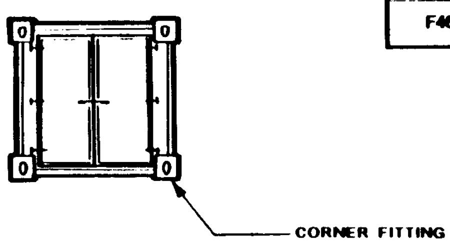
SPECIFICATIONS

MATERIAL:
CAST STEEL

STRENGTH:
MEETS STRENGTH REQUIREMENTS OF I.S.O. STANDARD 1161

FINISH:
SELF COLORED

MODEL NO.	DIM	A	B	C	D	E	F	WT KGS. (LBS.)
F463-2	MM	178.0	162.0	123.8	63.5	50.8	79.4	12.3
	(INCH)	(7.00)	(6.38)	(4.87)	(2.50)	(2.00)	(3.13)	(27.0)



APPLICATION

F463
CORNER FITTING
(BOTTOM I.S.O. CORNER FITTING)

Peck & Hale

PECK & HALE, INC.
100 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

FSCM NO:94658	DRN: S.M.	SHEET OF	
DATE: 10/24/91	APPD: S.J.	2023 DWG NO	REV
SCALE: NONE	Q.C.:		

Figure 3-9. ISO Corner Fitting (Bottom)

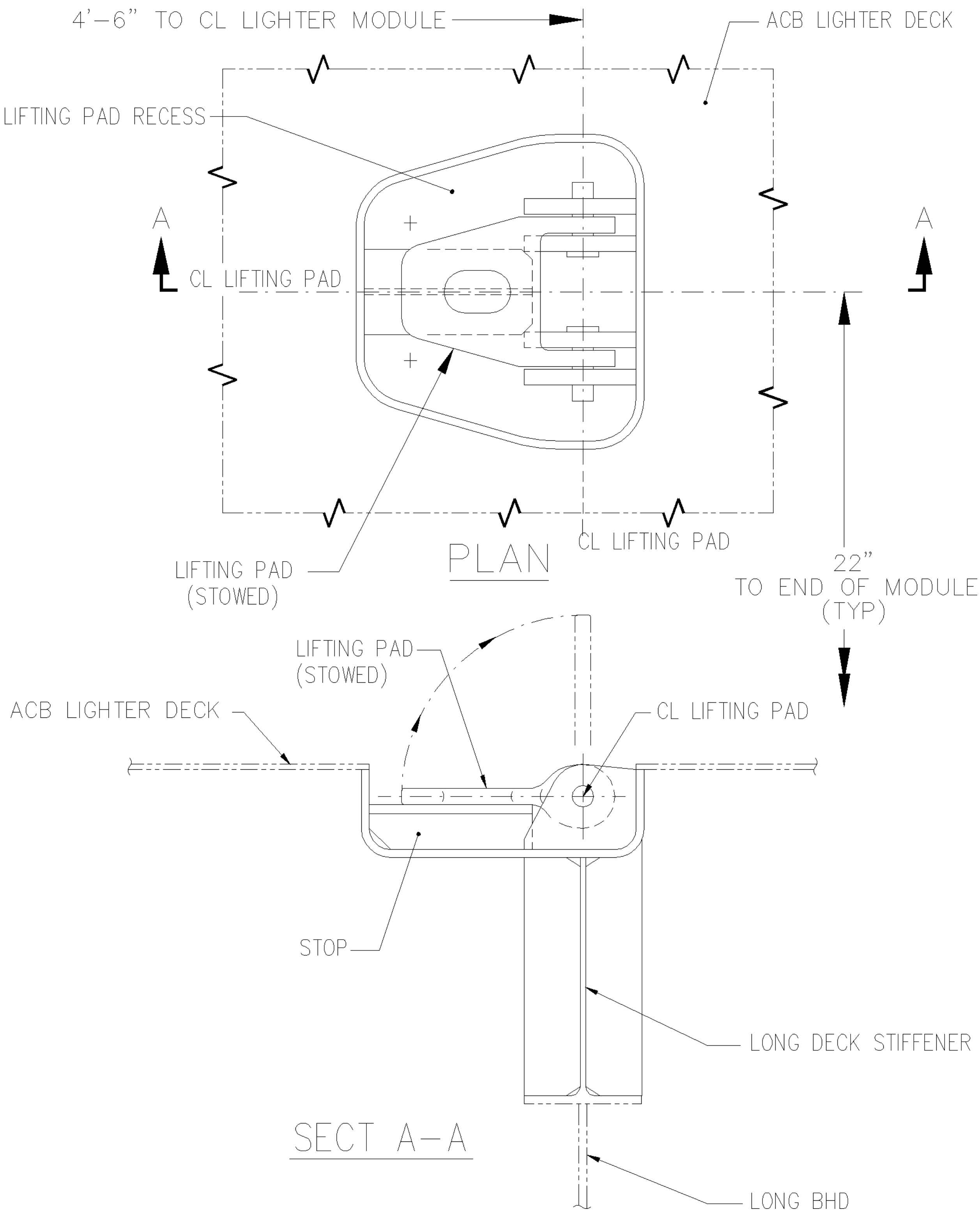
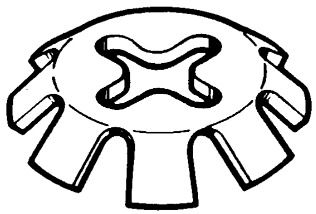


Figure 3-10. Hinged Lifting Pad

NEXT ASSEMBLY

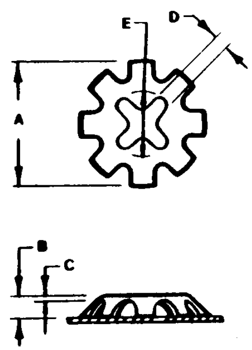
ISSUE	REVISION RECORD	DATE	APPD

F265
DECK SOCKET
(RAISED CLOVERLEAF)



DIMENSIONAL DATA

COMMERCIAL TOLERANCE APPLIES



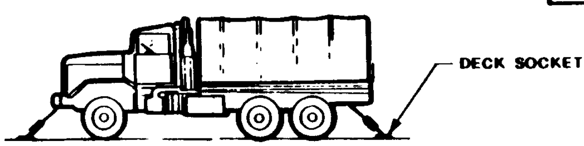
SPECIFICATIONS

MATERIAL:
CAST STEEL

STRENGTH:
35,000 LBS. M.B.S. AT 45° PULL PER SLOT

FINISH:
SELF COLORED

MODEL NO.	DIM	A	B	C	D	E	WT KGS. (LBS.)
F265-1C	MM	292.0	51.0	12.7	35.0	155.8	
	(INCH)	(11.50)	(2.00)	(0.50)	(1.38)	(6.13)	



APPLICATION

F265
DECK SOCKET
(RAISED CLOVERLEAF)

Peck & Hale

PECK & HALE, INC.
100 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

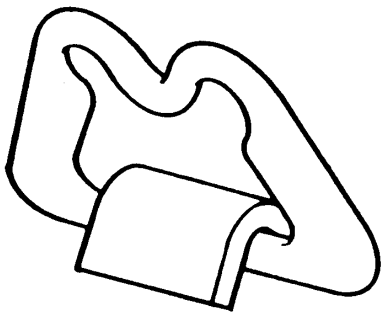
FSCM NO: 94850	DRN: S M	SHEET OF	
DATE: 10/23/91	APPD: S J.	3496 DWG NO	REV
SCALE: NONE	Q.C.:		

Figure 3-11. Deck Socket (Raised Cloverleaf)

NEXT ASSEMBLY

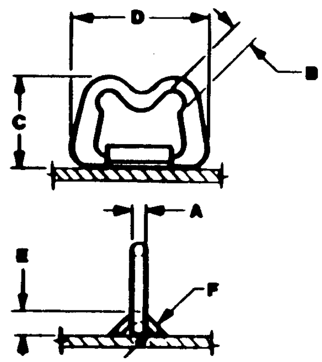
ISSUE	REVISION RECORD	DATE	APPD

F677
D-RING & STRAP
(CLOVERLEAF)



DIMENSIONAL DATA

COMMERCIAL TOLERANCE APPLIES



MODEL NO.	DIM	A	B	C	D	E	F	WT KGS. (LBS.)
F677-1/-2	MM	20.6	35.0	135.0	203.2	44.5	12.7	2.0
	(INCH)	(.812)	(1.37)	(5.31)	(8.00)	(1.75)	(0.500)	(4.4)

SPECIFICATIONS

MATERIAL:

D-RING - FORGED STEEL
STRAP - PLATE STEEL

STRENGTH:

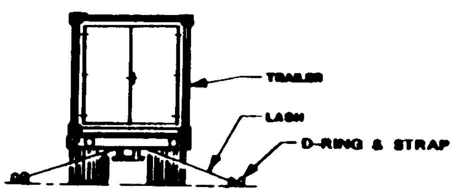
35,000 LBS. M.B.S. PULL AT 45° PER SLOT.

TESTING:

PROOF TESTED: 1 OF 50 UNITS TO 23,333 LBS.

FINISH:

BARE MILL STEEL.



APPLICATION

F677
D-RING & STRAP
(CLOVERLEAF)

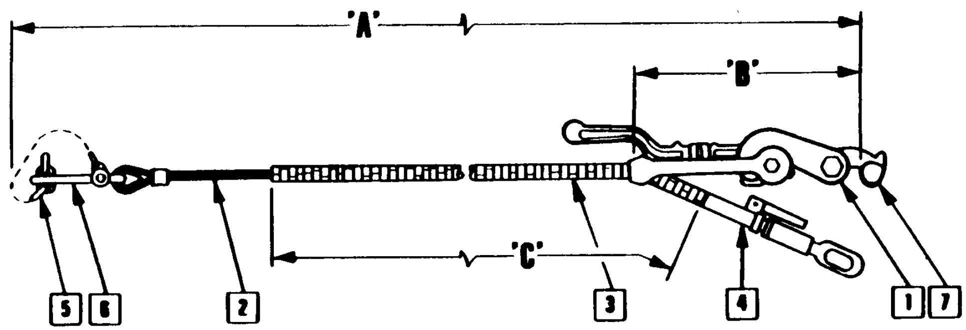
Peck & Hale

FSCM NO:	DRN: S M	SHEET 1 OF
DATE:	APPD: S J.	3524 DWG NO
SCALE:	Q.C.:	REV

Figure 3-12. D-Ring and Strap (Raised Cloverleaf)

NEXT ASSEMBLY	ISSUE	REVISION RECORD	DATE	APPD

35M/819
TIEDOWN ASSEMBLY
(VEHICLE)



SPECIFICATIONS

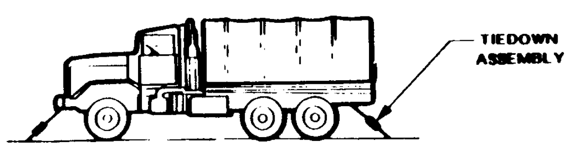
MATERIAL:
ALL CONSTRUCTION IS PER BEST COMMERCIAL QUALITY. SEE CHART BELOW FOR SPECIFIC MATERIAL.

STRENGTH:
35,000 LBS. M.B.S.

TESTING:
ASSEMBLY IS PROOF TESTED TO 17,500 LBS.

FINISH:
ALL SURFACE FINISHES PROVIDE GOOD CORROSION PROTECTION. SEE CHART BELOW FOR SPECIFIC FINISH.

MODEL No.	ADJUSTMENT 'A'	TENSIONER ASSEMBLY		WIRE ROPE ASSEMBLY	
		MODEL No.	'B'	MODEL No.	'C'
35M/819	59.00" TO 126.00"	35M-1/819	16.81"	35M-3/819A	123.00"



APPLICATION

ITEM NO	PART NO	PART NAME	DESCRIPTION
7	H71-1F-1	BULB HOOK	STEEL, GALV
6	PH324-1	CHAIN GRAB	STEEL, GALV
5	PH279-1	CHAIN BRIDLE, 1/2"	STEEL, GALV
4	PH750-8	HIGH TENSION UNIT	CRES
3	PH10-20	SPLIT BEAD	STEEL, CAD PLT
2	-	WIRE ROPE, 5/8" DIA	STEEL, GALV
1	PH4035-1	TENSIONER	STEEL, GALV/ CAD PLT

LIST OF MAJOR COMPONENTS

35M/819
TIEDOWN ASSEMBLY
(VEHICLE)

Peck & Hale
PECK & HALE, INC.
180 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

FSCM NO: 94658	DRN: F R M	SHEET OF	
DATE: 7/25/91	APPD: S J	1248 DWG NO	REV
SCALE: NONE	Q.C.:		

Figure 3-13. Vehicle Tie Down Assembly

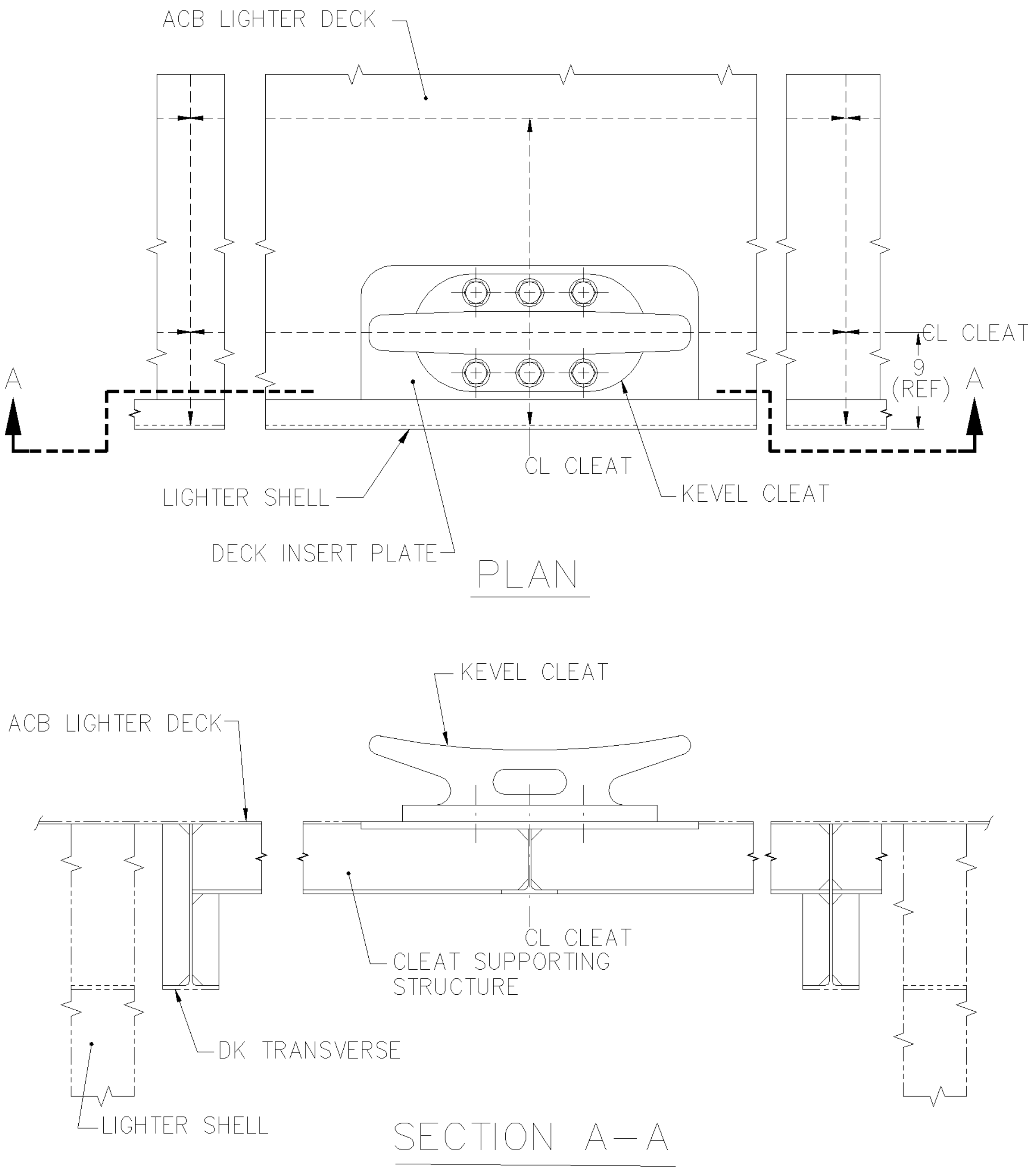
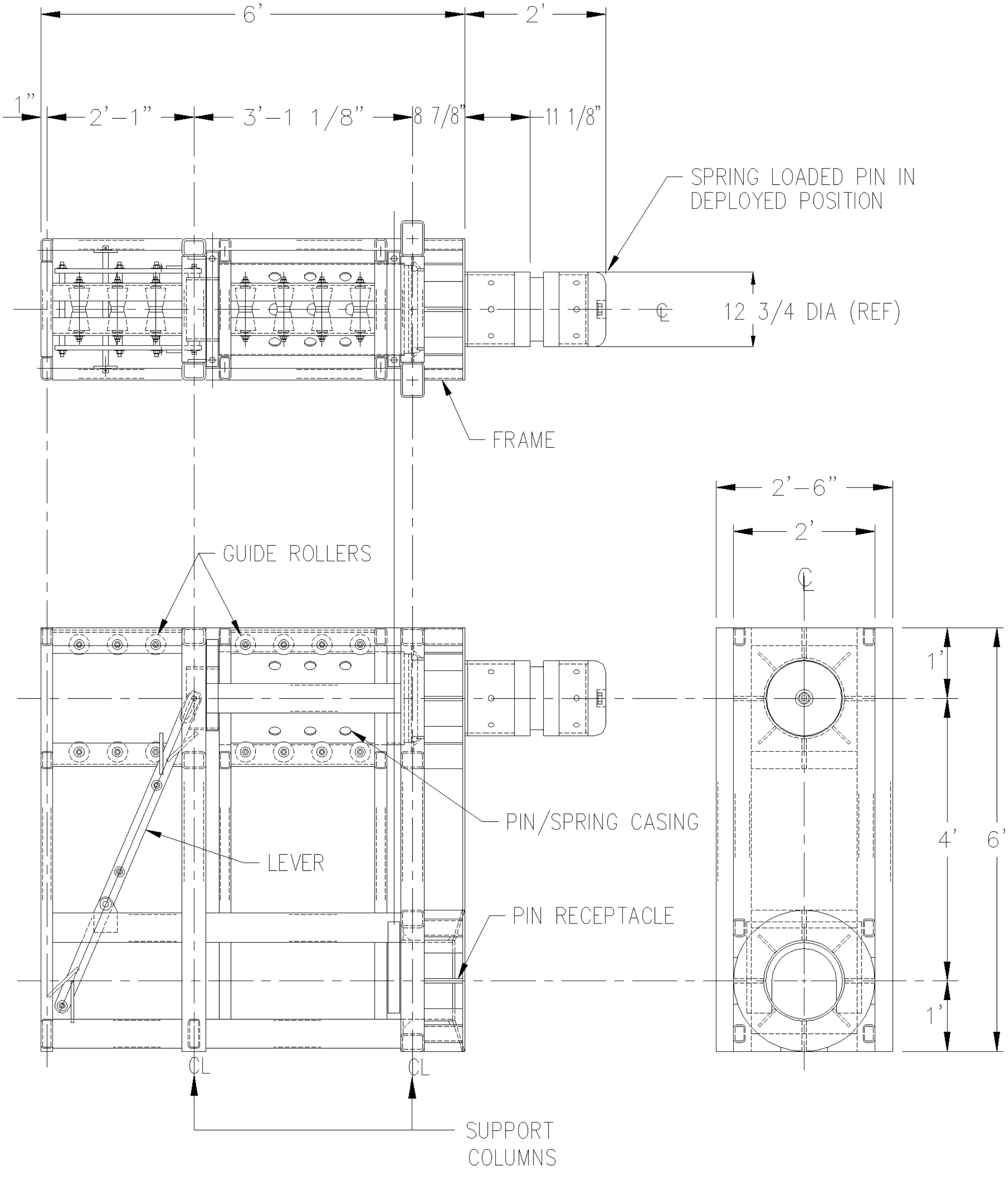


Figure 3-14. Bolted Kevel Cleat (Removable)



FOR END TO END AND SIDE TO SIDE CONNECTION OF ACB LIGHTER MODULES
ESTIMATED UNIT WT: 3,000 LBS

Figure 3-15. NFESC Developed Rigid Connector Assembly (RCA)

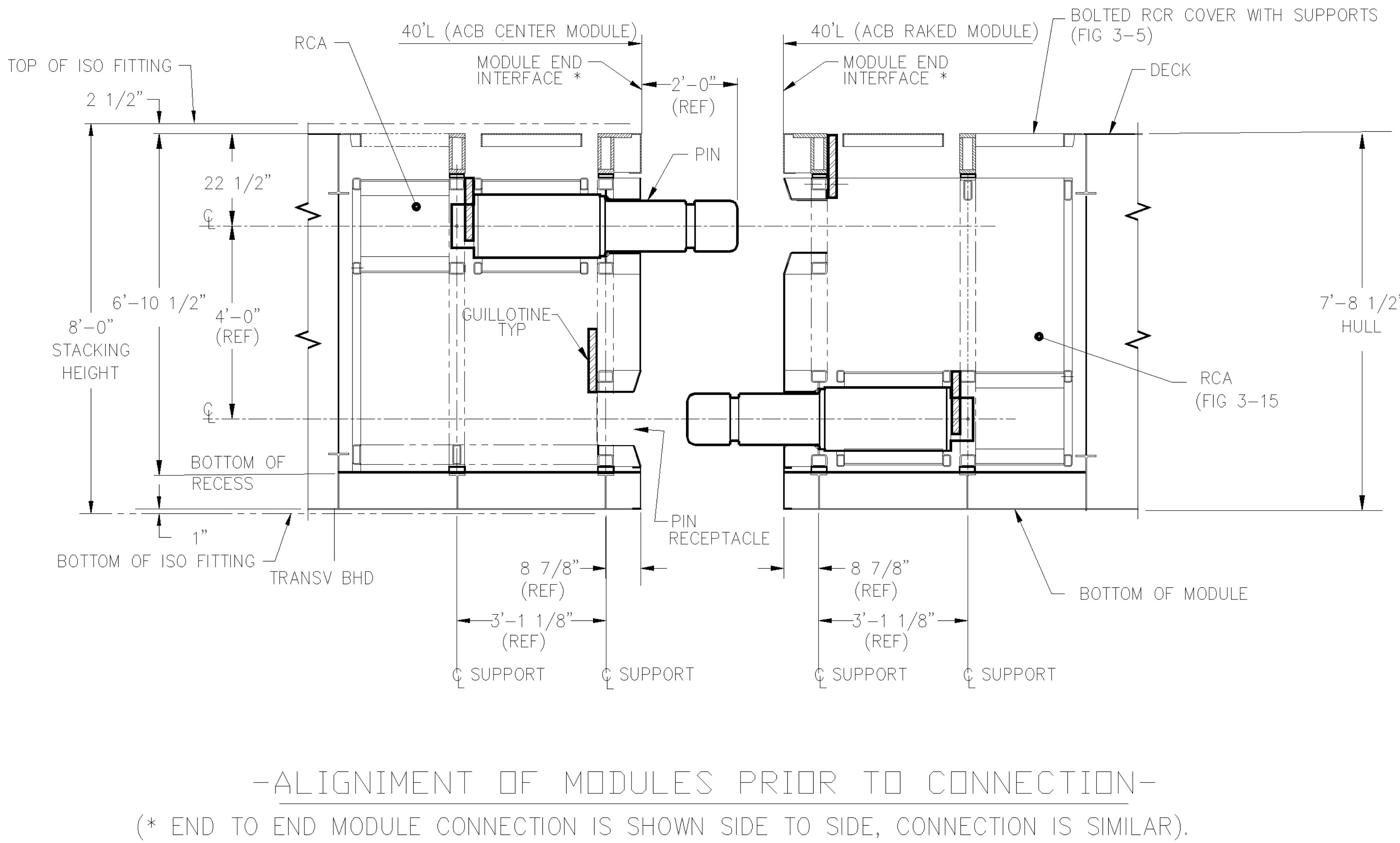
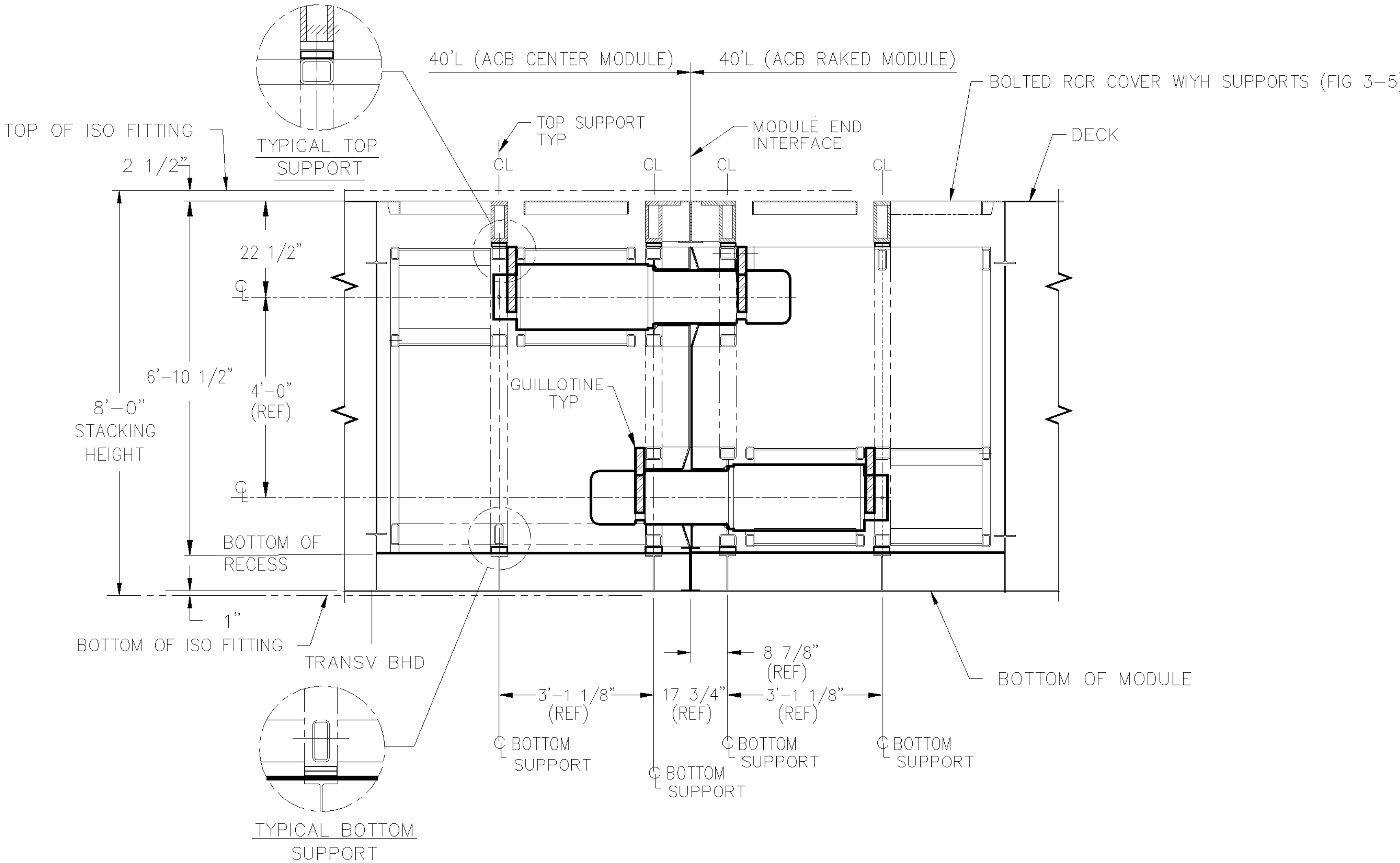


Figure 3-16. Connection of ACB Modules with RCAs (Sheet 1 of 2)



-ALIGNIMENT OF MODULES AFTER CONNECTION-

Figure 3-16
Sh. 2 of 2

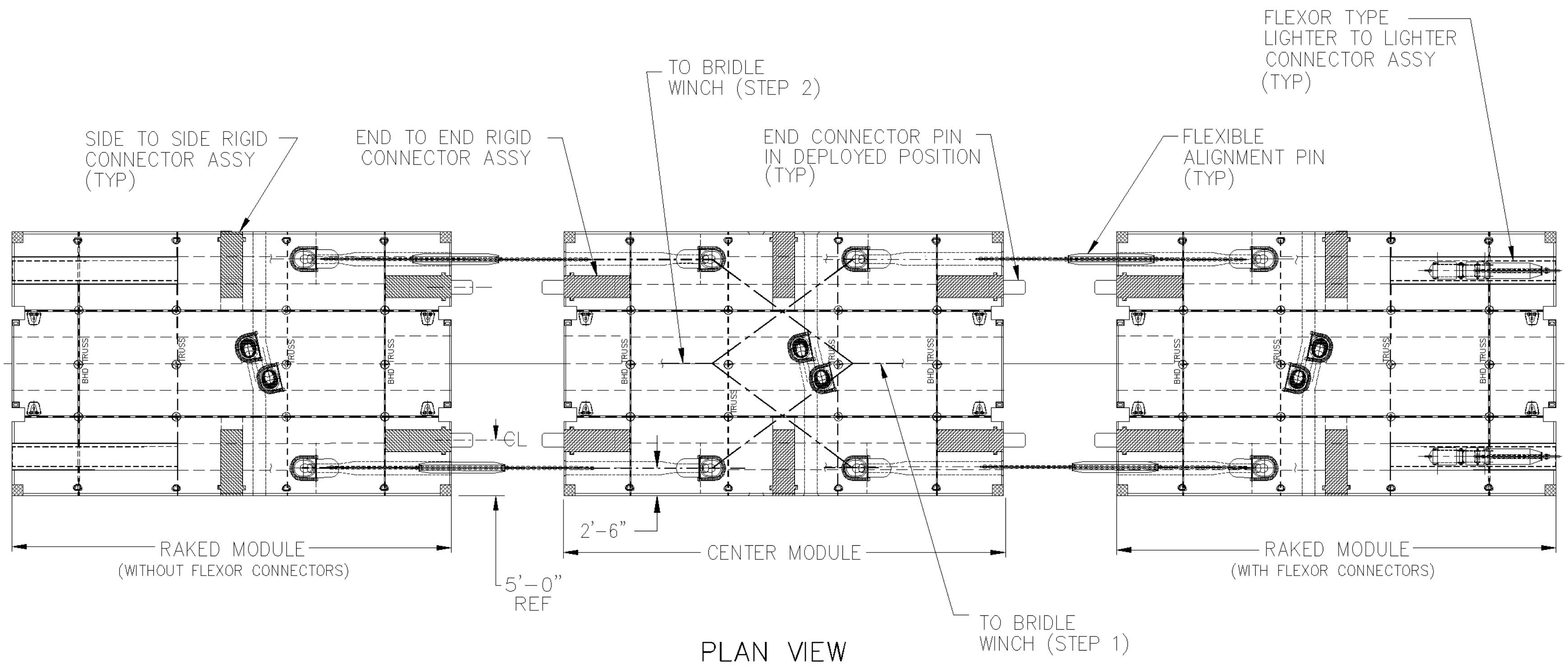


Figure 3-17. End to End Connection of ACB Lighter Modules

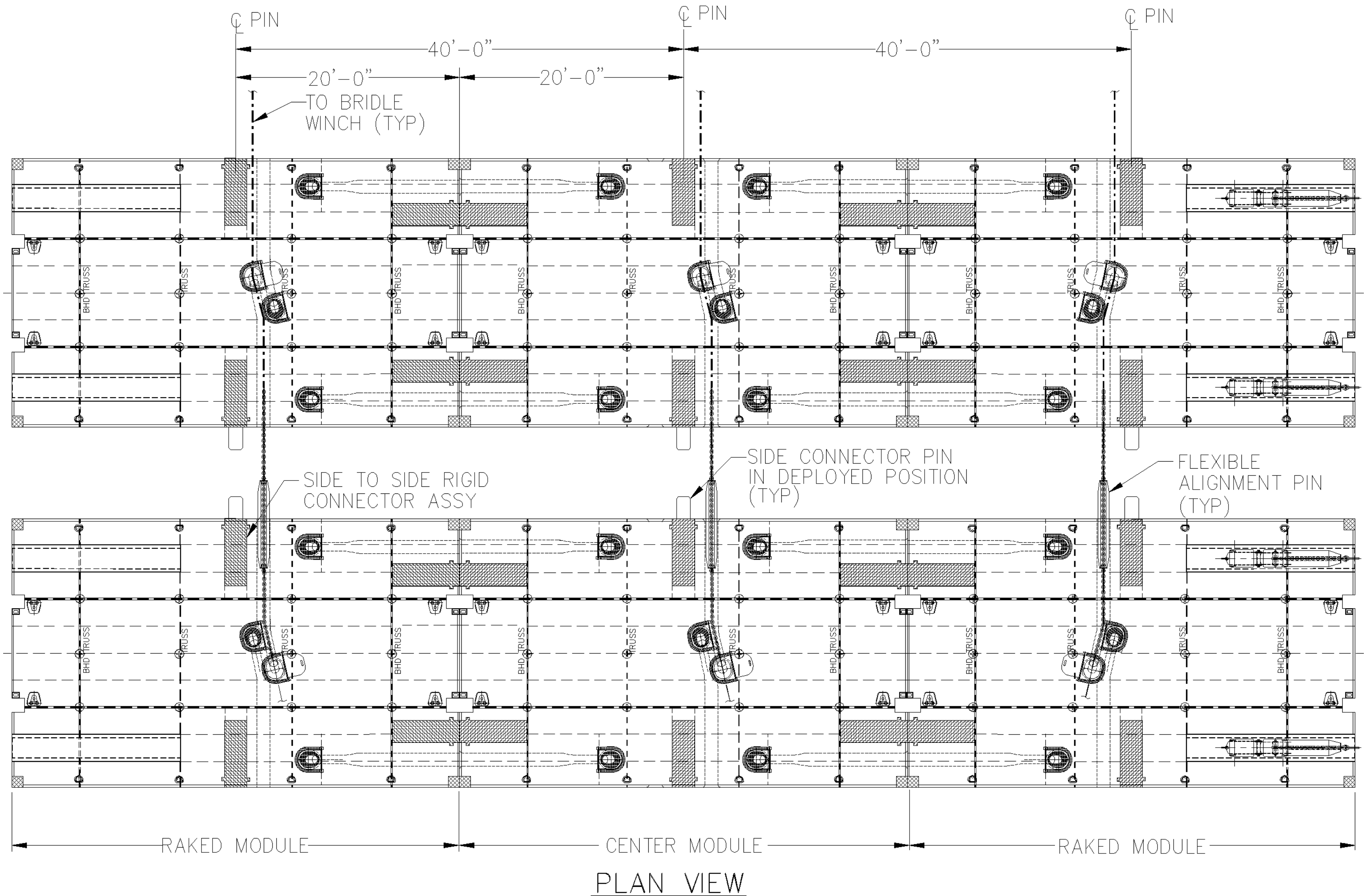


Figure 3-18. Side to Side Connection of ACB Lighters

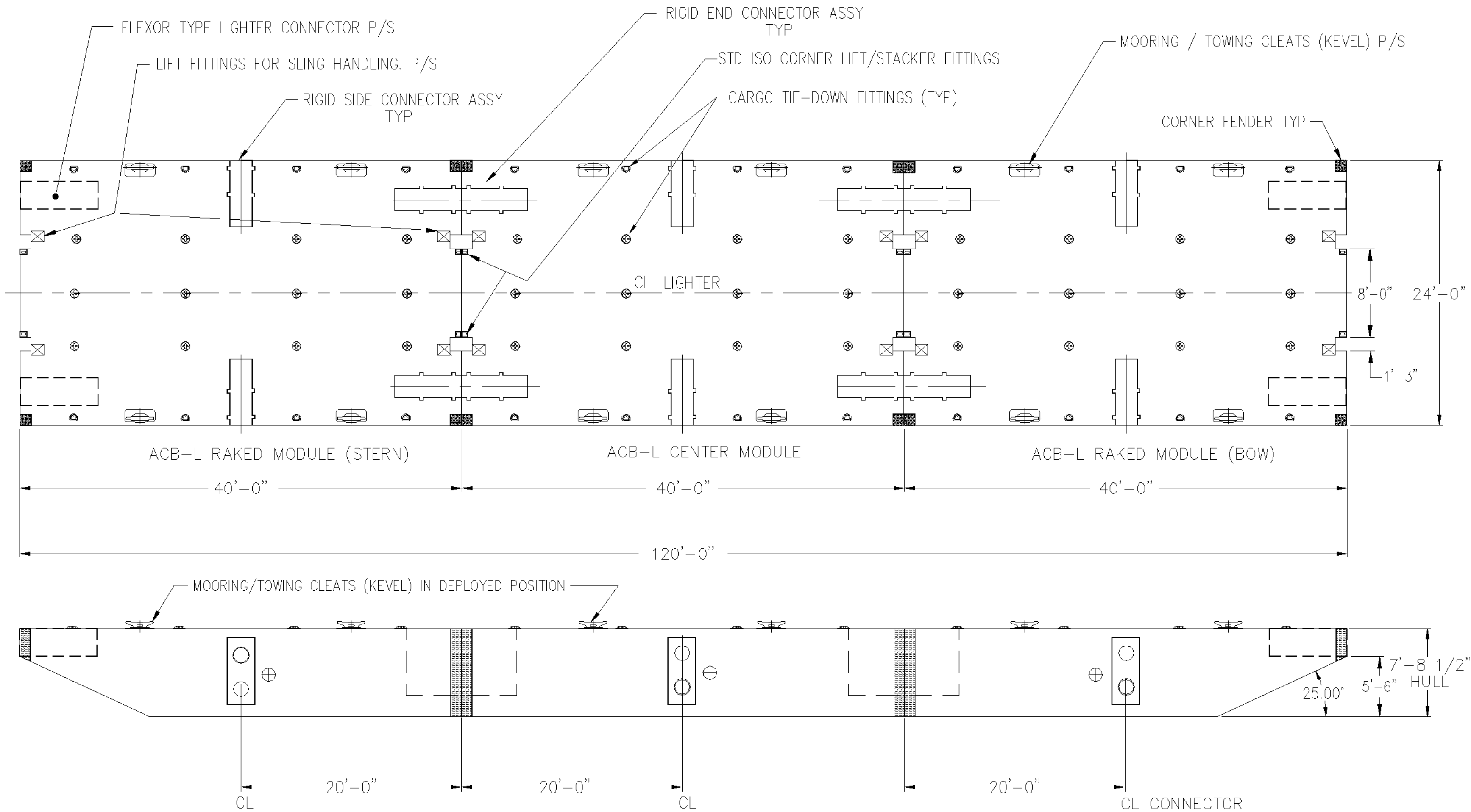


Figure 3-19. Modular ACB Lighter General Arrangement & Key Dimensions

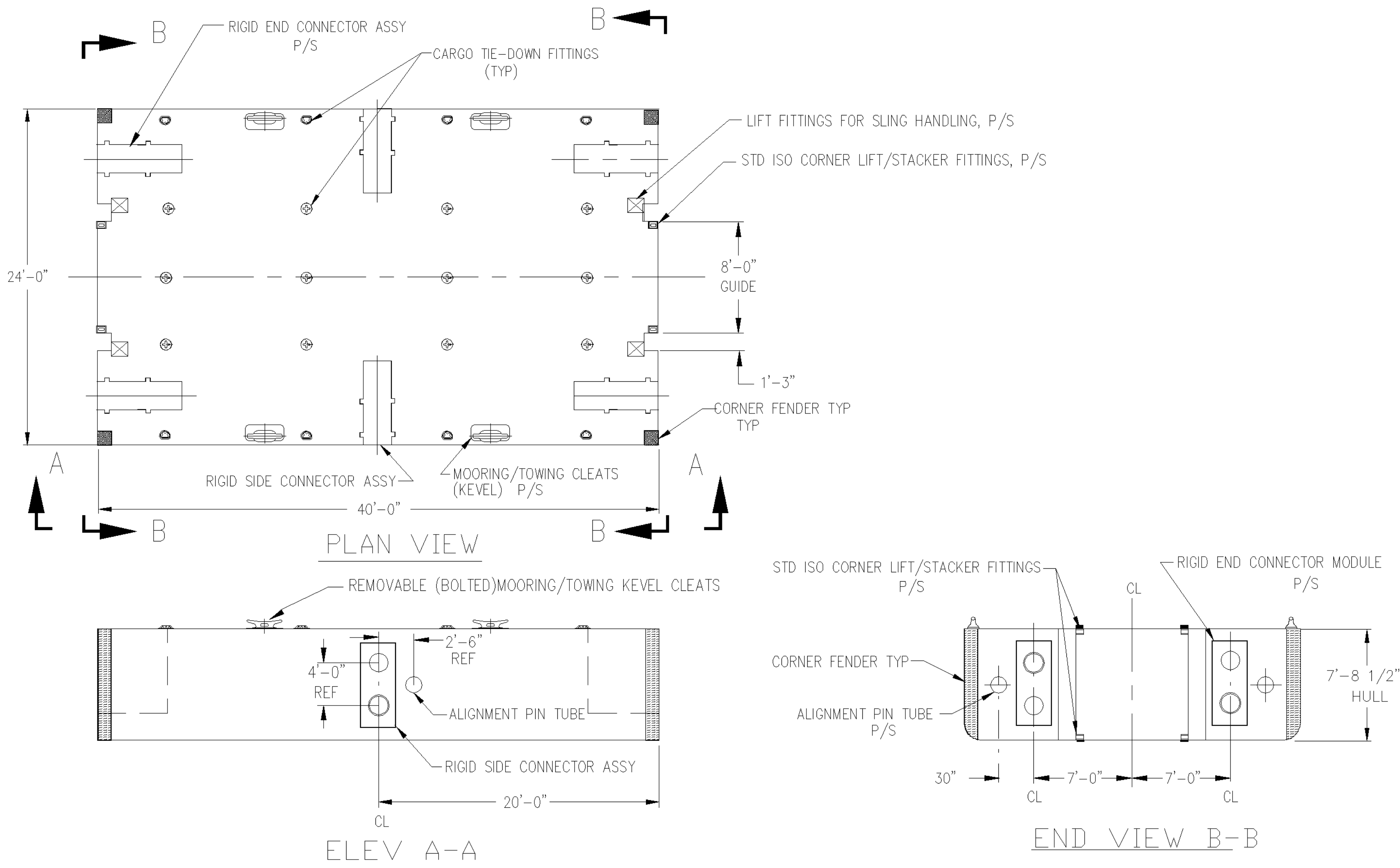


Figure 3-20. ACB Lighter Center Module General Arrangement

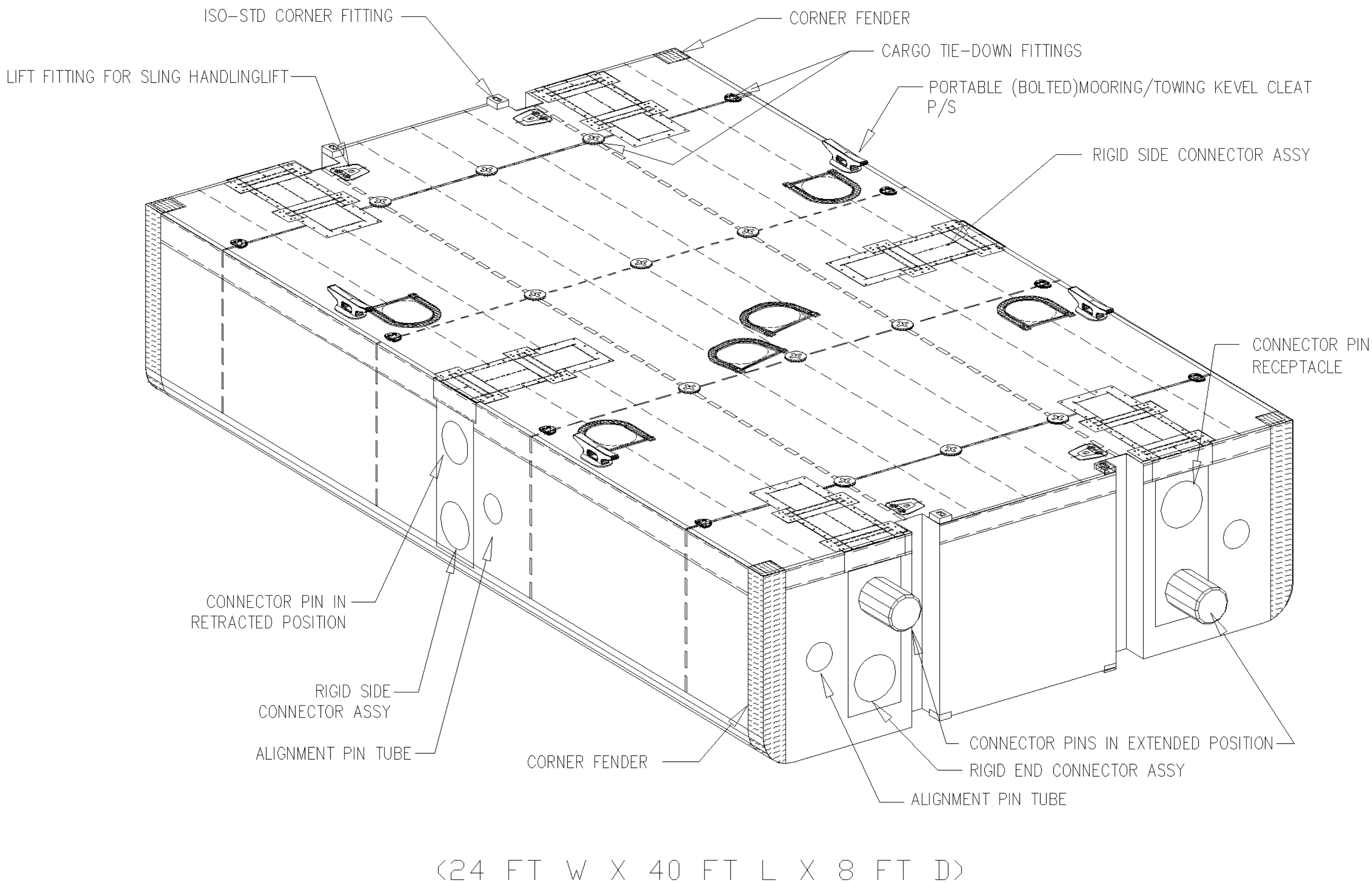


Figure 3-21. ACB Lighter Center Module Isometric View

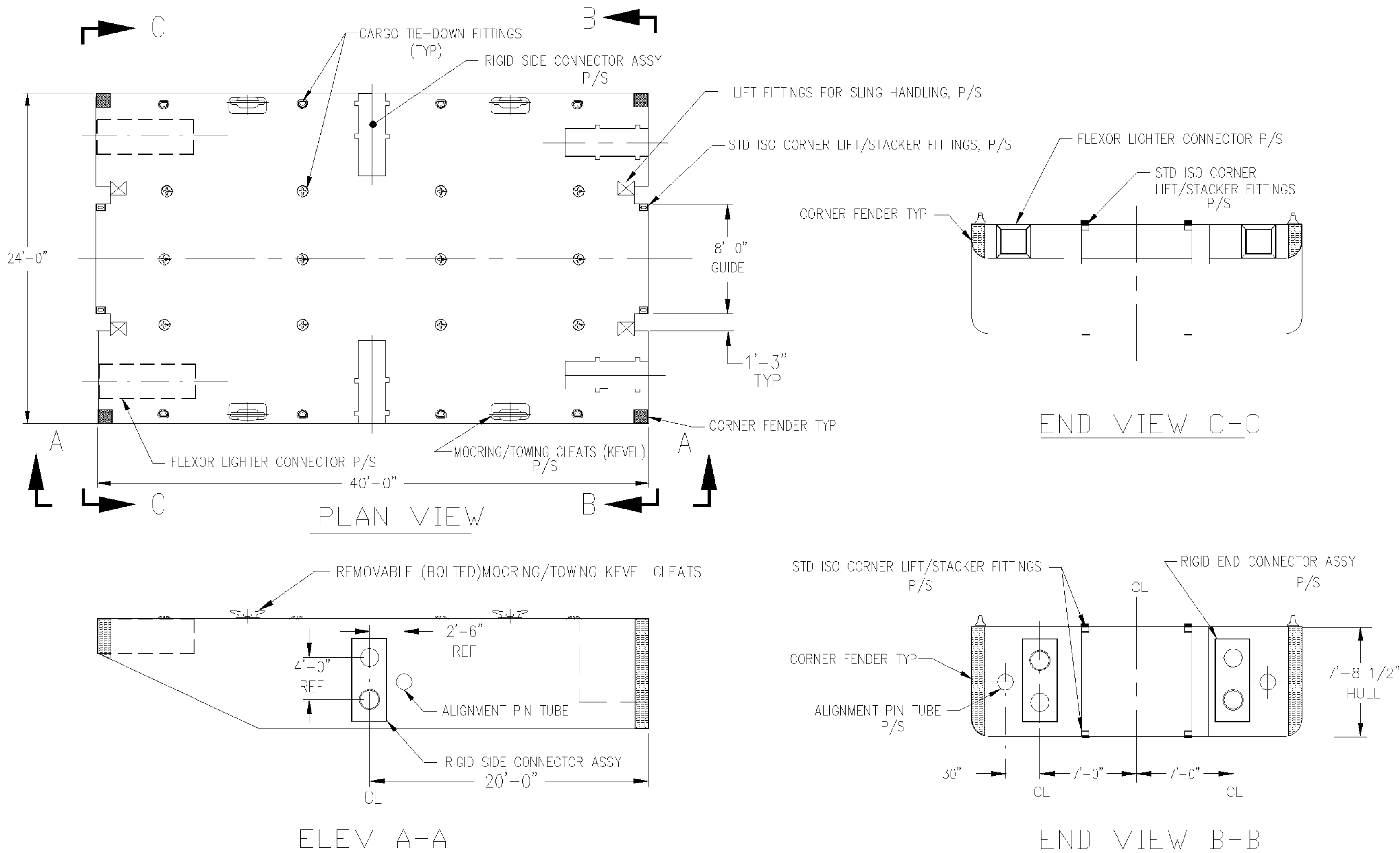


Figure 3-22. ACB Lighter Raked (Bow/Stern) Module General Arrangement

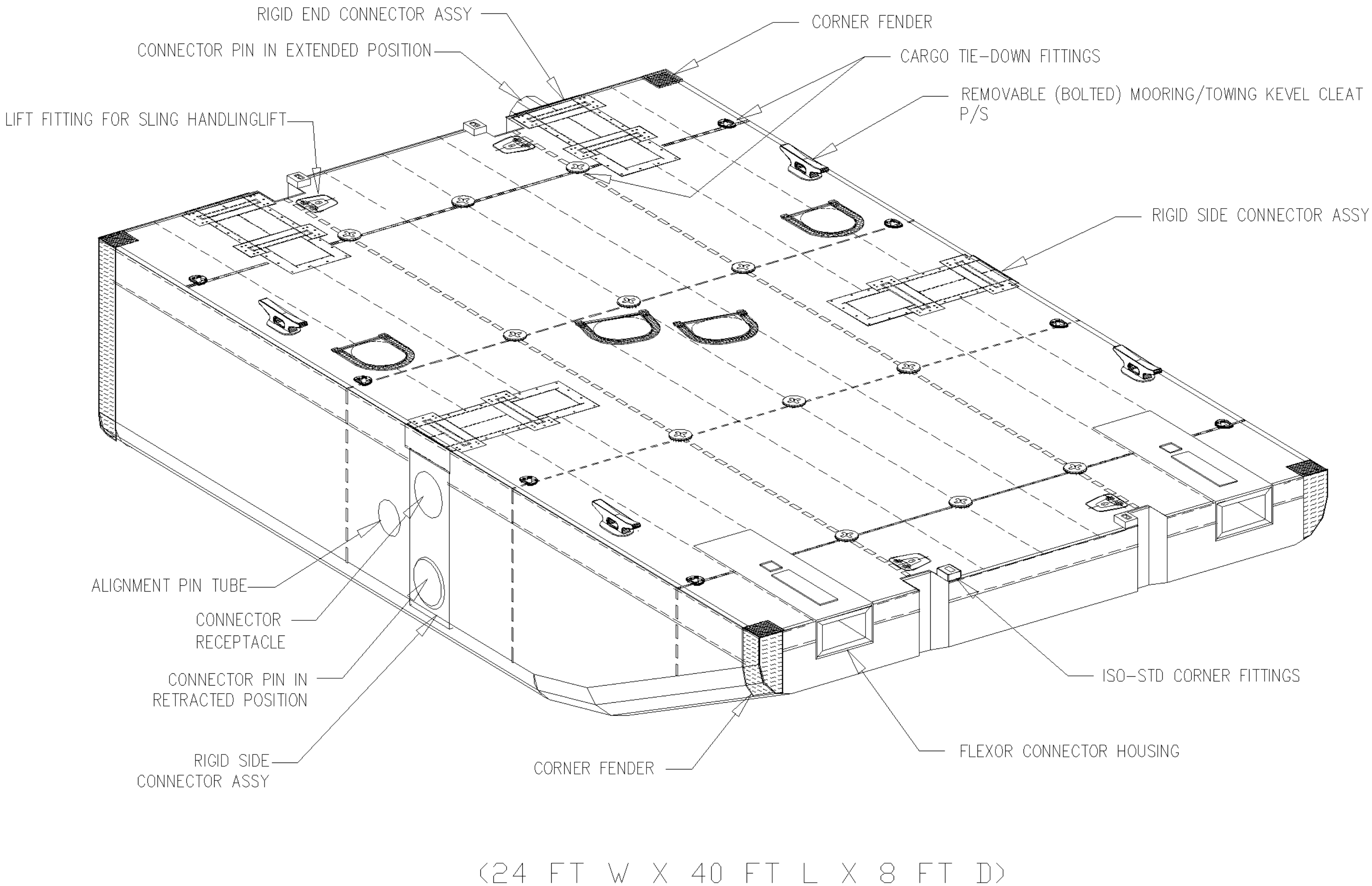


Figure 3-23. ACB Lighter Raked (Bow/Stern) Module Isometric View at Raked End

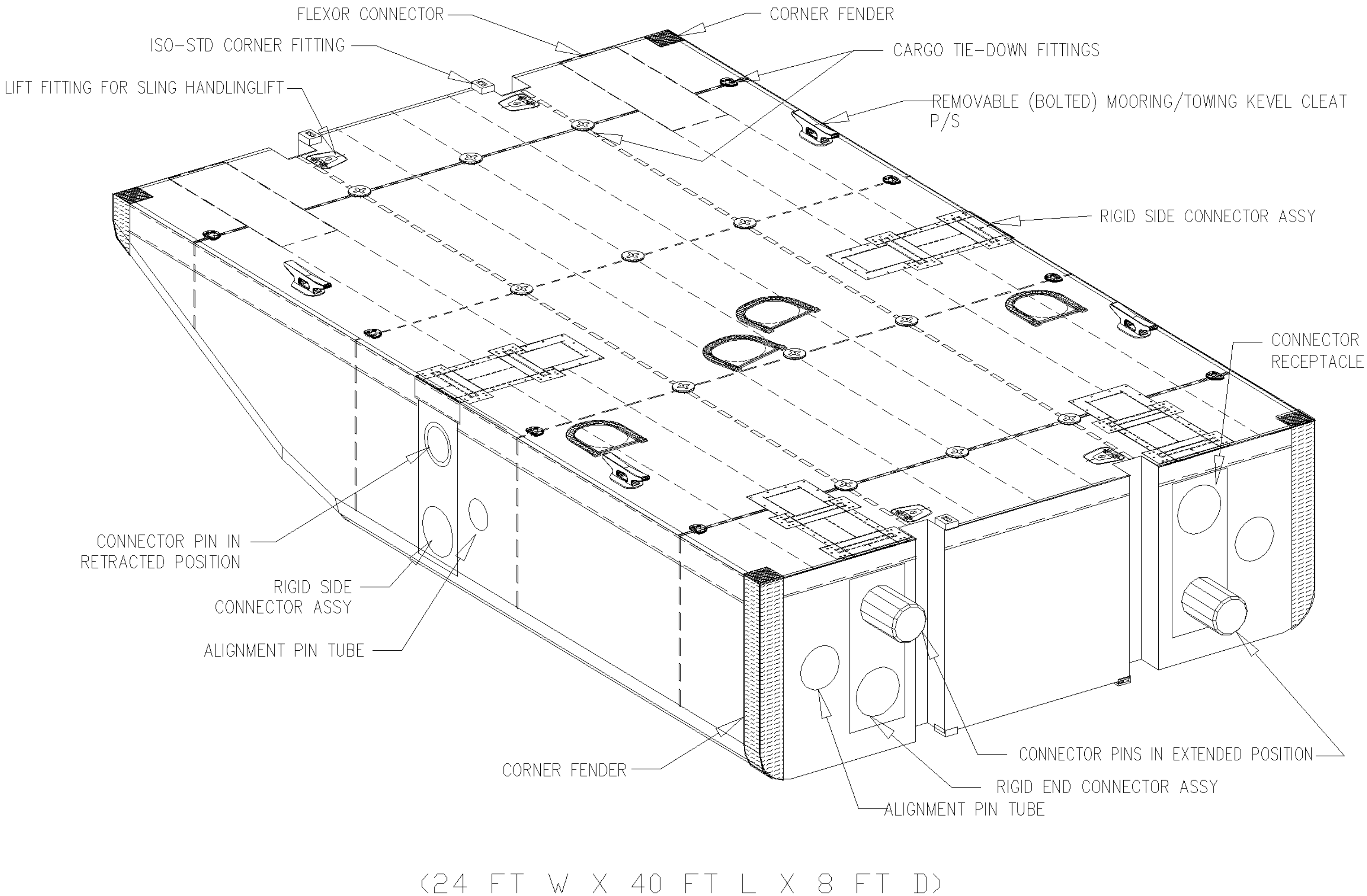


Figure 3-24. ACB Lighter Raked (Bow/Stern) Module Isometric View at Rigid Connection End

4.0 CONTAINER HOLD/CELL GUIDE INTERFACE REQUIREMENTS

One of the basic objectives of the ACB Lighter concept is to increase the transportability options of the lighter modules by making the modules suitable for insertion and stacking in 40 foot container holds of commercial container ships and Navy transport ships such as the Auxiliary Crane Ship (T-ACS). This capability makes the transportation of modules possible in large numbers inside container holds, where the modules would be stacked in lighter sets.

Cargo holds, suitable for transportation of the ACB lighter modules, must meet the requirements defined in Section 4.1. The ACB lighter modules must also incorporate some of the necessary ISO requirements of standard 40 foot cargo containers for container hold/guide interface. The module container guide interface requirements are discussed in Section 4.2. The stacking options of modules in container guides are discussed in Section 4.3. Comparison of stacking loads, commercial ISO containers vs. ACB Lighter modules is presented in Section 4.4.

4.1 Cargo Hold and Cell Guide Requirements

The cargo hold of a transport ship must meet the following requirements for stacking and transporting the 24 foot wide by 40 foot long by 8 foot deep lighter modules.

a. The container hold must be equipped with fixed cell guides suitable for the transportation of standard 40 foot ISO containers.

b. The hold must have a minimum of three adjacent container cells to accommodate the 24 foot wide modules as shown in Figure 4-1.

c. The ACB Lighter modules are supported, similarly to a standard 40 ft ISO container, at the four tank top container support points of the center container cell. Ideally, for maximum utilization of the available stacking height, the three adjacent container cells should have the same depth as shown in Figure 4-2. However, some differences in cell depth can be eliminated by either using a flatrack or an ISO container as a base on the bottom of the center cell.

d. The required minimum container cell depth (measured from the underside of the hatch cover structure to the top surface at the container support pads at the bottom of the cell guides) must be at least 8’-6", 16’-6", 24’-6", 32’-6", 40’-6" or 48’-6" to accommodate a stack of 1, 2, 3, 4, 5 or a maximum of 6 ACB lighter modules respectively, as shown in Figure 4-2. The minimum required cell depths were calculated with an 8’-0" stacking height for each module and a 6 inch clearance allowance between the underside of the hatch cover structure and the top of the upper most module in the stack.

4.2 ACB Module Interface Requirements

The standard container cell guide, face to face, inside width is 8’-1" as indicated in center guide section of each module is 8’-0" wide the same as the width of a standard ISO container. The guide section will provide guidance for the modules during loading the modules into the cell guides. The distance between two adjacent container cells is non-standard and varies from ship to ship. Planviews A and B of Figure 4-1 show the anticipated minimum and maximum distances for adjacent cell guides. The module structure adjacent to the 8’-0" wide guide surface of the module, is provided with an 1’-3" wide by 1’-0" deep notch as shown, to clear the outboard cell guides.

4.3 Stacking of Modules in Cell Guides

As shown in Figure 4-2, the ACB lighter modules will be stacked in 40 foot container guides. Two sets of ACB Lighter modules are stacked as shown. The stacking height of the modules is 8’-0". The stack of modules are supported at the four (4) container support points of the center container cell, similarly to supporting a six high stack of 40 foot ISO containers.

4.4 Stacking Loads

A typical container cell of a container hold may carry a six high stack of standard 40 foot ISO cargo containers as shown in Figure 4-2. Since the maximum allowable gross weight for each 40 foot container is 30 LT, the maximum stack load supported by the four tank top container supports is 180 LT as shown for Case #1 in Table 4-1. The load bearing capacity of the container supports are subject to regulatory agency approval. When the American Bureau of Shipping (ABS) is the regulatory agency the anticipated maximum static container support load is the basis for approval. In case of a six high container stack the maximum static load rating of each container support may be set at 45 LT as indicated for Case #1 in Table 4-1. When the container stack is replaced with a six high stack of ACB Lighter modules as shown in Figure 4-2 and when the stacking weights of the modules (center and raked) meet the 30 LT design objective, the six high lighter module stack weight and the related container support loads would be equal to the weight and loads imposed by the container stack as indicated for Case #2 in Table 4-1. However, based on the results of this study, MR&S believes that the 30 LT handling weight objective for the modules can not be achieved with the present design approach. As shown in Tables 3-4.1 and 3-4.2, the estimated excess handling weights for the center and raked modules are 32,544 lbs or 14.53 LT and 16,459 lbs or 7.35 LT respectively. The excess weights are mainly due to the weight impact by the NFESC developed rigid connector assemblies and the related extensive structural foundations. This weight impact is so large that it can not be offset by other weight savings. Only a different, structurally less intrusive connector design can reduce the excess stacking weight of the modules. Nevertheless, based on the present results the estimated module stack weight and the related container support loads by the heavier than 30 LT modules are listed under Case #3 in Table 4-1. As shown, the estimated average container support load of 59.61 LT is approximately 32.4 percent in excess of the loads imposed by the container stack. Therefore, in order to carry the heavier modules in a six high stack, comprising of two complete ACB Lighter sets, the container support structure may have to be reinforced and recertified by ABS for the heavier loads. This approach was also accepted for the Navy’s SEA SHED program when similar overload conditions occurred. As an option, to prevent the overload condition a four or five high stack of modules could be transported without requiring ship modifications. This approach, while cost effective, would make the transportation of lighter modules in sets more difficult.

TABLE 4-1
COMPARISON OF CONTAINER SUPPORT LOADS

		A	B	C	D	
CASE #	DESCRIPTION	STACK HEIGHT (SEE FIG 4-2)	UNIT WT (LT)	STACK WT A X B (LT)	AVERAGE CONT. SUPP LOAD (C/4) (LT)	SEE NOTE
1	Std. 40 ft ISO cargo container	6	30	180	45 (100%)	1
2	ACB Lighter Module(s) (Design Objective)	6	30	180	45 (100%)	2
3	ACB Lighter Module(s) (Phase II Configuration)	6	39.74	238.46	59.61 (132.4%)	3

NOTES:

1. 67,200 lbs = 30 LT, maximum permissible gross handling weight of a standard 40 ft ISO cargo container.

2. The original design objective for maximum ACB Lighter Module (center or raked) handling/stacking weight is 30 LT as defined in Section 2.0 of this report.

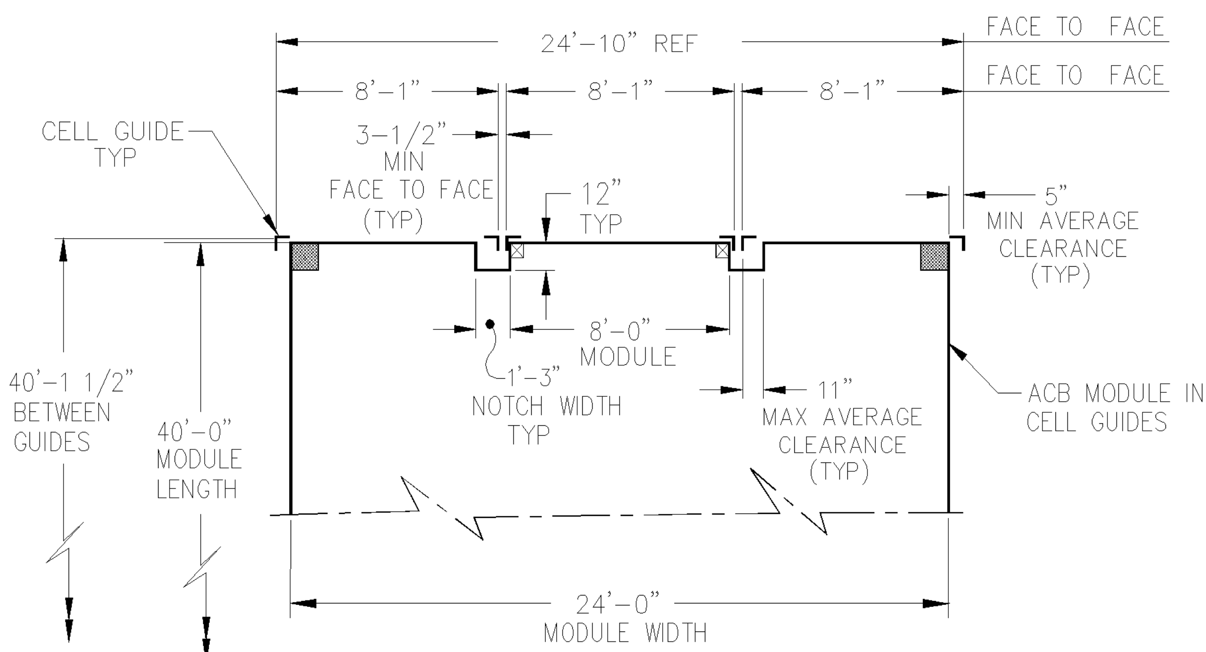
3. Phase II estimated weights are as follows:

   a. The calculated handling/stacking weight for an ACB center module (see item 16 of Table 3-4.1) is 99,744 lbs = 44.53 LT.

   b. The calculated handling/stacking weight for an ACB raked module (see item 16 of Table 3-4.2) is 83,659 lbs = 37.35 LT.

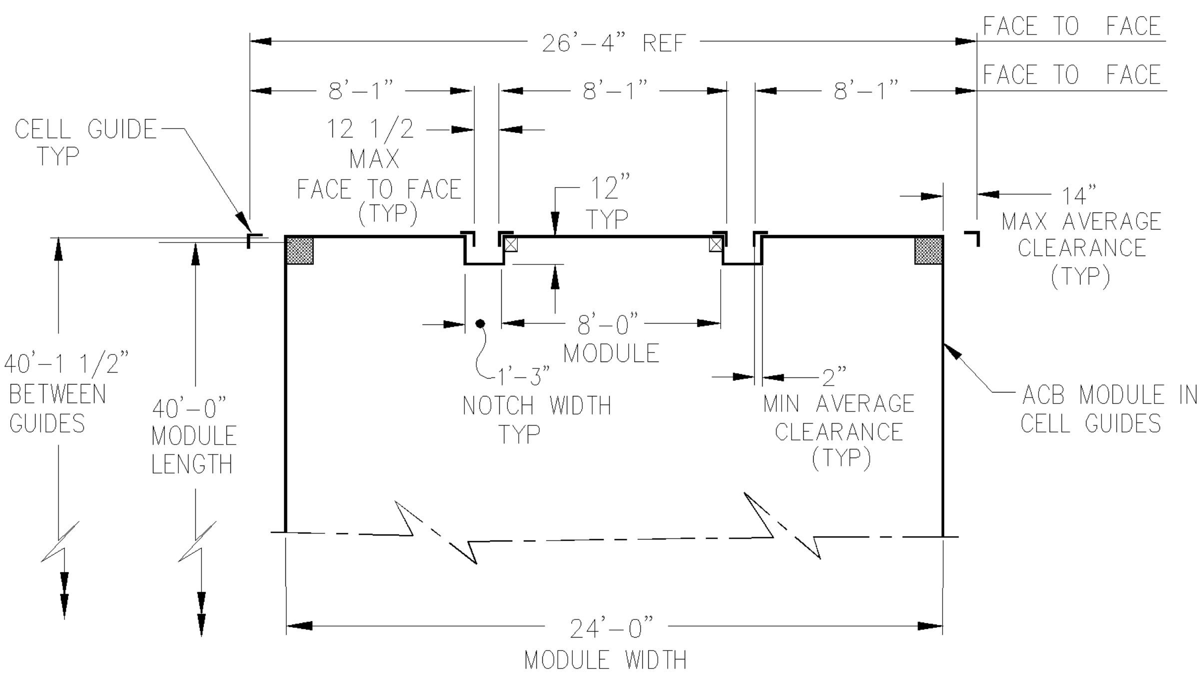
   c. The calculated stack weight of six ACB Lighter Modules, two lighter sets as shown in Figure 4-2 is 2 x 44.53 LT + 4 x 37.35 LT = 238.46 LT.

The “average” module weight shown for Case #3 in Column B is one sixth of the estimated stack weight, while the average container support load(s) listed in Column D are one fourth of the stack weights.



PLAN VIEW "A"

MIN CONTAINER CELL GUIDE SPACINGS & CLEARANCES



PLAN VIEW "B"

MAX CONTAINER CELL GUIDE SPACINGS & CLEARANCES

Figure 4-1. ACB Lighter Module and Cell Guide Interface

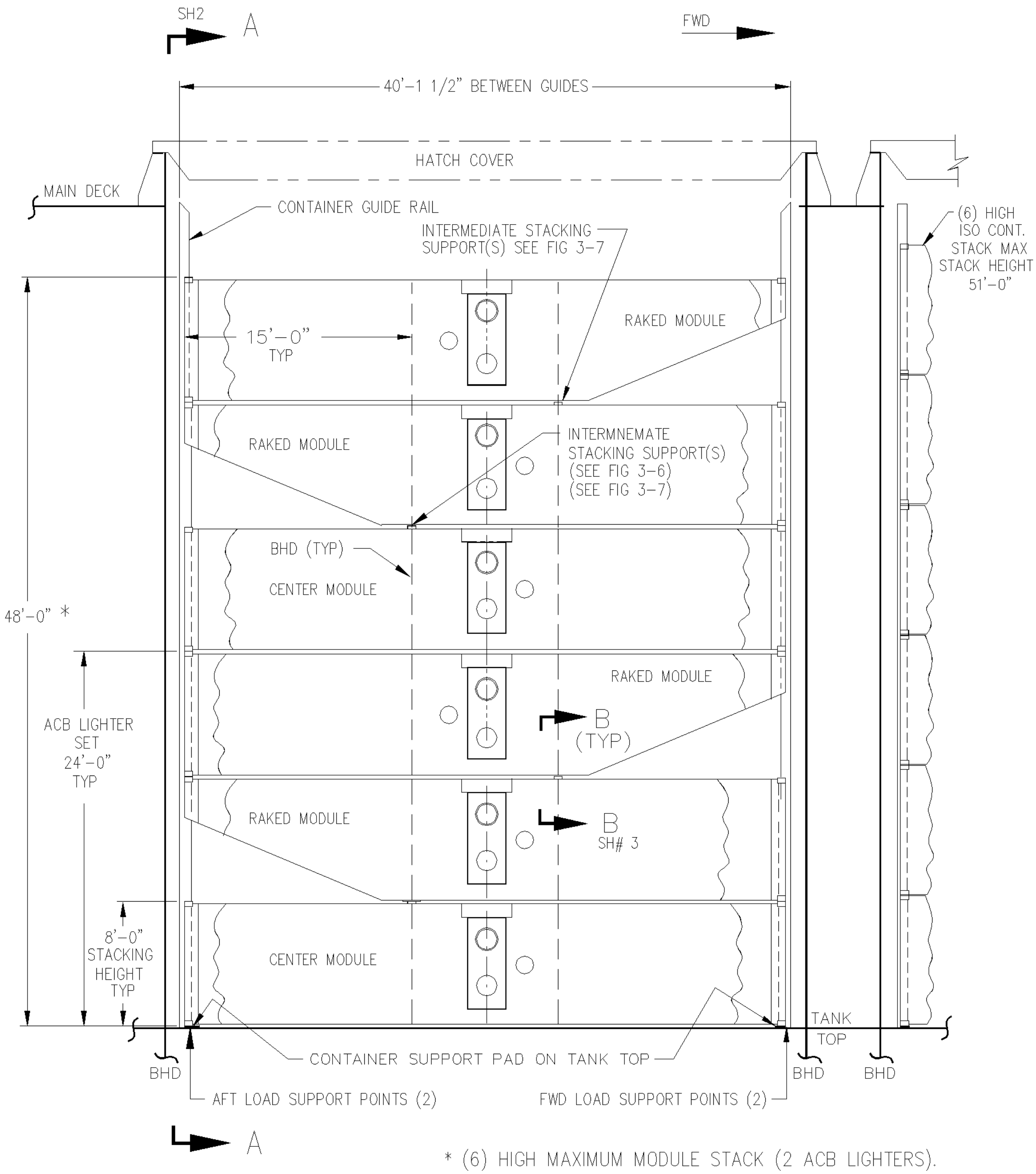


Figure 4-2. ACB Lighter Modules Stacked in 40FT Cell Guides (Sheet 1 of 3)

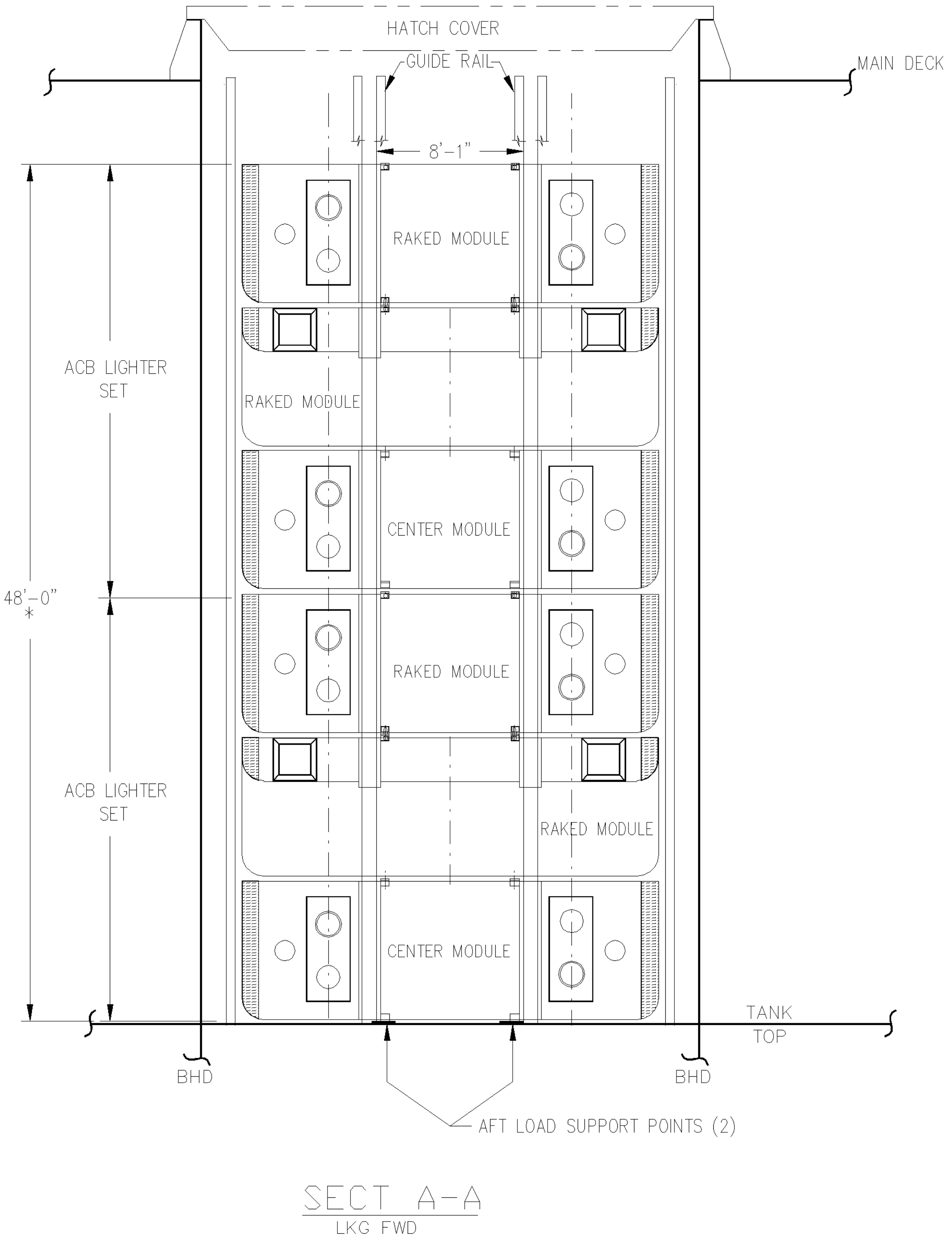


Figure 4-2
Sh. 2 of 3

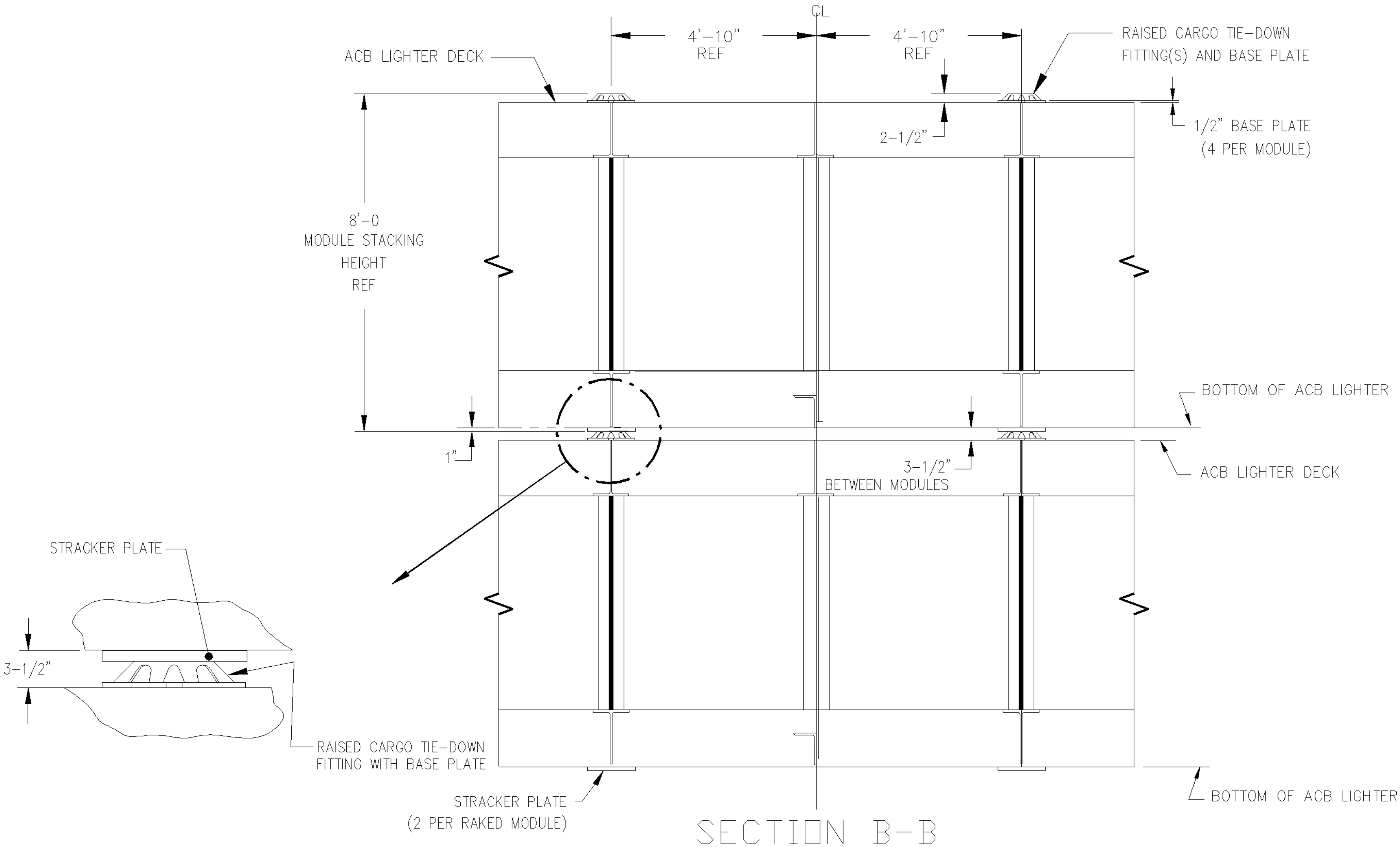


Figure 4-2
Sh. 3 of 3

5.0 HANDLING

In order to maximize the intermodal features of the ACB Lighter Modules, from the standpoint of handling and transportation, the original design objective for module handling weight has been set at 67,200 lbs, (30 LT) maximum. This handling weight limit is the same as the maximum allowable gross handling weight of a standard 40 foot ISO cargo container. The intent of the 30 LT handling weight limit for the lighter modules was to ensure that the handling of the modules would be possible with any existing standard 40 foot container spreader, standard container cranes and container trailers or chassis which are commonly used in containership terminals.

The results of this study indicate that with the present weight budget for the NFESC developed modular connector assemblies and the additional structural weight increase due to the large recesses required for the connector assemblies in the hull structure and related foundations in way of the connector installations the 30 LT module handling weight design objective can not be achieved. MR&S estimated in this study that the actual handling weight for the center and raked modules of the ACB Lighter would be 99,744 lbs or 44.35 LT and 83,659 lbs or 37.75 LT as shown in Tables 3-.4.1 and 3-4.2, respectively. These estimated handling weights are about 14.35 LT and 7.35 LT in excess of the design objective. Therefore the handling of the ACB Lighter modules in commercial container terminals using standard 30 LT capacity container handling gear would not be permissible.

However, some of the new and updated commercial container handling facilities, in addition to the standard 30 LT capacity handling equipment, may also have high capacity container cranes and container spreaders with up to 50 LT load capacity under the spreader. One example of this high capacity equipment is the ASX7 type universal container spreader manufactured by Bromma Inc. of Roxboro, N.C. This particular spreader, suitable for handling 20 Ft, 40 Ft and 45 Ft long standard ISO cargo containers, can also handle up to 50 LT concentric loads and up to 40 LT loads when the load center has a 10% offset relative to the center of the four pick-up points (twist locks), see Reference (10). The spreader is equipped with standard ISO size twist locks for handling. It should be noted that the standard topside ISO container corner fittings and twist locks have sufficient margin in their safety factors that allow the safe handling of the higher loads, see Reference (11).

Container crane manufacturers such as Paceco Corp. of San Mateo C.A., manufacture high capacity container cranes which can utilize the 50 LT capacity spreaders. The estimated 44.35 LT and 37.75 LT respective handling weights for the ACB Lighter center and raked modules are within the stated capabilities of the high capacity handling equipment.

Therefore, commercial container terminals and military cargo terminals equipped with this high capacity handling gear could handle (load/offload) the ACB Lighter modules. However, it can reasonably be assumed that the stockpiling and portside handling of the ACB Lighter modules will not take place in commercial container terminals but rather in designated cargo terminals of the Military Sealift Command (MSC).

The ACB Lighter modules are outfitted with two independent sets of topside handling fittings as shown in Figures 3-6 and 3-7 for the center and raked modules respectively. The first set of handling fittings consists of four standard ISO container corner fittings (see Figure 3-8) installed in accordance with ISO STD 668 for handling with a 40 FT container spreader as shown in Figure 5-1.

The second set of fittings consist of four hinged lifting pads (see Figure 3-10) for handling with a four point sling as shown in Figure 5-2.

5.1 Handling Scenarios

5.1.1 Inside Terminal Handling

a. Assumptions:

- ACB Lighter modules will be stockpiled at designated military cargo terminals.
- Modules will be stacked three high
- Each stack will be a lighter set

b. Stacking and Transportation to Pierside

When the modules are stacked or removed from stack, a boom type mobile crane can be used either with a high capacity 40 FT container spreader with four point sling and manually operated twist locks which will engage the four topside ISO carrier fittings on the module as shown in Figure 5-1, or with a four point lifting bridle which will be attached to the four top side lifting pads on the module as shown in Figures 5-2.

For inside terminal transportation of the modules the standard 30 LT capacity commercial container trailers and chassis can not be used. However, finding a suitable flatbed truck or tailer in the military vehicle inventory should be possible. Modules would be transported from the stacking area to the pierside for loading onboard container ships. At pierside handling when the modules are loaded into container holds, either high capacity container cranes with spreaders or boom type heavy lift cranes such as the cranes of the T-ACS with four point lifting bridle can be used.

5.1.2 Offshore Handling

During Logistics Over The Shore (LOTS) operations when the ACB Lighter modules are offloaded into the water the heavy lift cranes of the T-ACS will be used with four point lifting bridles. Using container spreaders for this handling scenario would be dangerous to personnel and the release of the spreader twist locks may not be possible under Sea State 3 operating conditions.

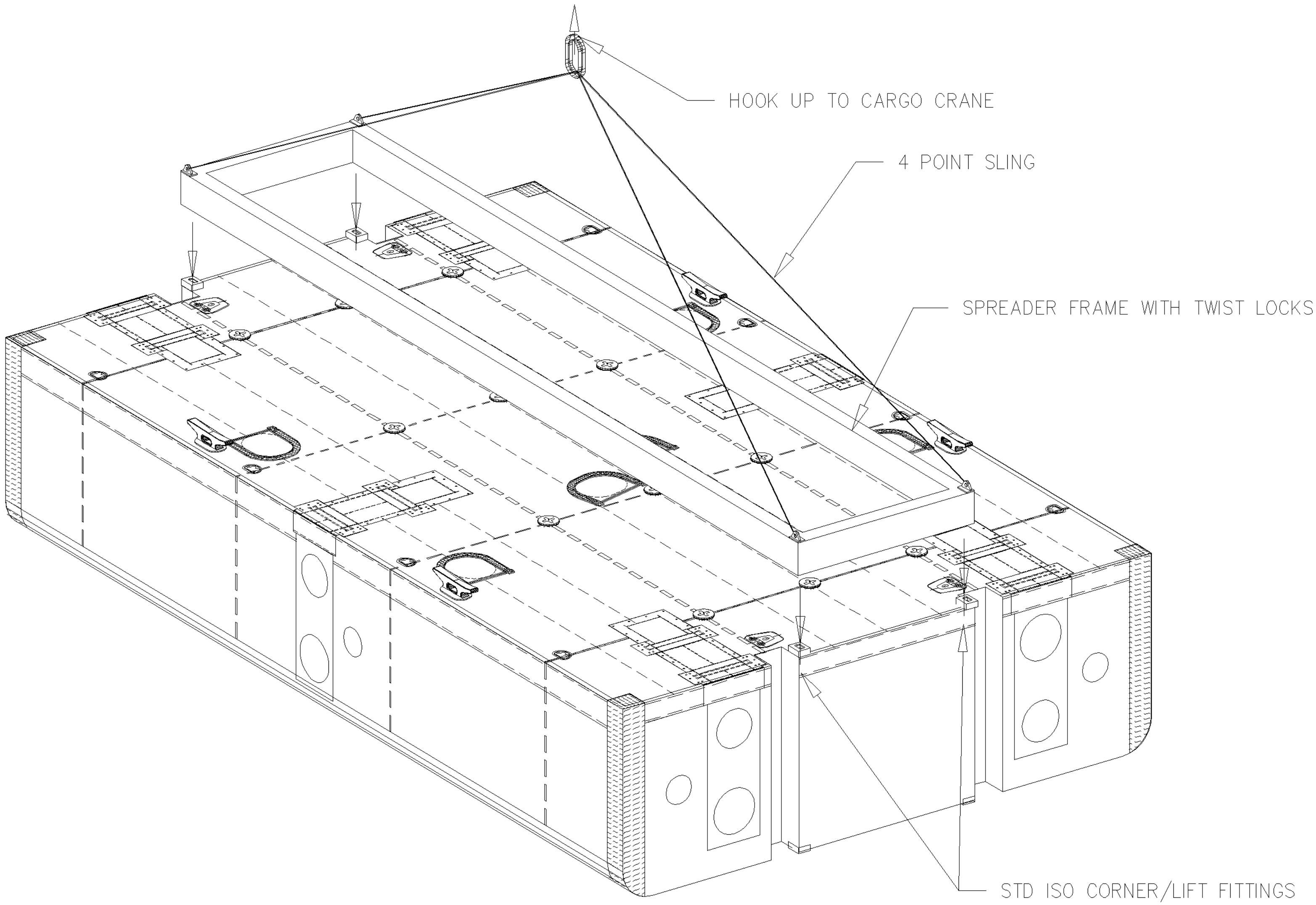


Figure 5-1. ACB Lighter Center Module Handling with 40FT Container Spreader

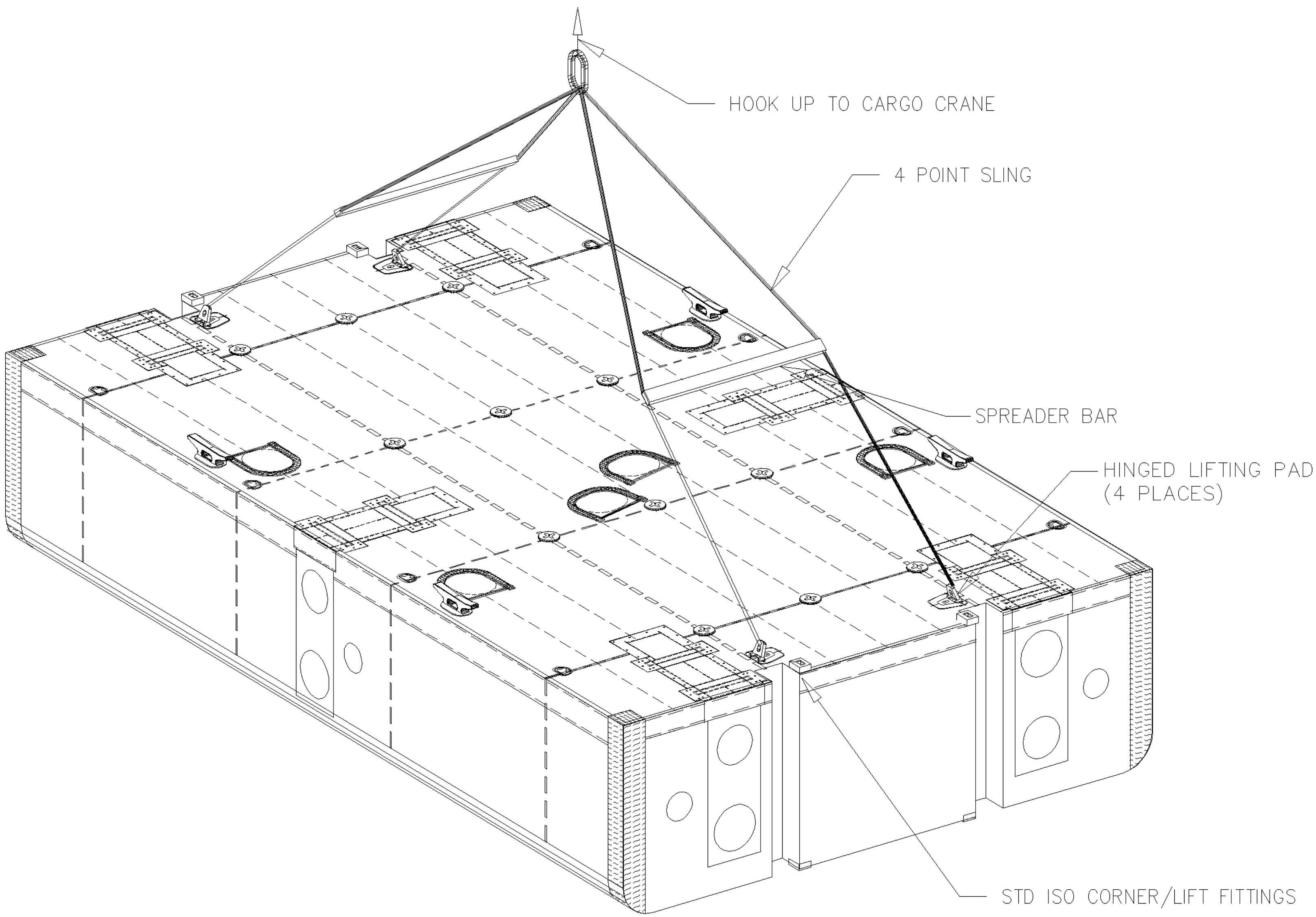


Figure 5-2. ACB Lighter Center Module Handling with 4 Point Sling

6.0 SUMMARY AND RECOMMENDATIONS

6.1 Summary

This report documents the results of the second phase effort performed by M. Rosenblatt & Son, Inc. (MR&S) under NFESC Contract N47408-95-C-0211. The report addresses several critical issues germane to the Advanced Modular Lighterage/Development Program. The key building block of this program is the modular Amphibious Cargo Beaching (ACB) Lighter, being developed by NFESC Code ESC31.

6.1.1 Objectives and Results

The objectives of this second phase effort by MR&S are defined in Section 1.1. The following is the summary of the results:

a. The final development of the recommended ACB Lighter structural design criteria for steel construction has been completed and the results are presented in Section 3. For the design criteria, selected rules from the ACB River Barge Rules, Reference (4), have either been adapted unchanged or when required were adapted with modification to make them suitable for the ACB Lighter structural design. In addition a proven commercial RO-RO ship design procedure for the ACB Lighter deck plating were adapted in accordance with Reference (2), "Design for Deck Structures Under Wheel Loads" by R.I. Jackson and P.A. Frieze.

   In order to verify the magnitude of the attainable hull structure weight savings, relative to the Phase I Study results, Reference (1), MR&S performed a Phase II preliminary scantling design and weight estimate for the ACB Lighter hull structure. The preliminary design was performed in accordance with the recommended structural design criteria presented in Section 3.2 of this study.

   The calculated scantling sizes for the 8 ft deep by 24 ft wide by 40 ft long center and raked modules are shown in Figures 3-1 and 3-2 respectively.

   The comparison study made between the Phase I and Phase II estimated scantling weights of the center or raked module structures is presented below. The Phase I estimated scantling weights are taken from Tables 3-5.8 and 3-5.9 of Reference (1), the comparable Phase II estimated scantling weights are listed in Tables 3-1 and 3-2 of this report.

Comparison of Phase I and Phase II estimated scanting weights:	Center Module (lbs)	Raked Module (lbs)
1. Estimated Phase I Basic Scantling Wt *(*)*:	58,411	54,811
2. Estimated Phase II Basic Scantling Wt *(*)*:	53,544	50,245
3. Estimated Phase II Basic Scantling Wt Inc/(Dec), (1-2):	(4,867)	(4,566)

(*) *Does not include the weight impact at the connector recesses and related foundations.*

The results indicate that the comparable basic scantling weight of the center and raked module structures were reduced in the Phase II preliminary design by 4,867 lbs and 4,566 lbs, respectively.

The reductions in scantling weights were made possible by the revised design criteria in Section 3.2.3.2. This criteria specifies a 20% higher allowable bending stress than the Phase I allowable bending stress. The results met the Phase II objectives for basic structural weight reduction.

b. In order to make a realistic assessment of the structural weight impact of the connector recesses and foundations in way of the NFESC rigid connector assembly installations a connector assembly hull integration study was performed by MR&S. Due to the large size of the recesses (see Figures 3-3 and 3-4) and the large connector imposed loadings on the structure the impact on the structural weight was found to be considerable. MR&S estimated the net structural weight increases caused by the recesses and the built-in connector foundations. The estimated weights are listed in Tables 3-1 and 3-2 as 11,430 lbs for the six (6) center module recesses and 8,088 lbs for the four (4) raked module recesses. These additional structural weights raise the total estimated scantling weights of the center and raked module structures to 64,974 lbs and 58,333 lbs respectively. Thus the connector recess related structural weight increases, which were not calculated in the Phase I Study, have increased the Phase II estimated total scantling weights of the center and raked module structures by 6,553 lbs and 3,522 lbs over the corresponding Phase I weights.

c. Selection of fitting types were made and their arrangements were developed. In addition, weight impact study of the ACB Lighter service suitable hull mounted fittings for stacking, handling, cargo tie down and mooring was completed. The recommended fittings arrangements for the center and raked modules are shown in Figures 3-6 and 3-7 respectively. The estimated hull fitting weights are 6,880 lbs and 5,206 lbs for the center and raked modules respectively as shown in Table 3-3.

d. The estimated handling weights for the center and raked modules are 99,744 lbs or 44.35 LT and 83,659 lbs or 37.75 LT as shown in Tables 3-.4.1 and 3-4.2, respectively. These estimated handling weights are about 14.35 LT and 7.35 LT in excess of the design objective. Therefore the handling of the ACB Lighter modules in commercial container terminals using standard 30 LT capacity container handling gear would not be permissible.

However, some of the new and updated commercial container handling facilities, in addition to the standard 30 LT capacity handling equipment, may also have high capacity container cranes and container spreaders with up to 50 LT load capacity under the spreader (see Section 5.0).

Container crane manufacturers such as Paceco Corp. of San Mateo C.A., manufacture high capacity container cranes which can utilize the 50 LT capacity spreaders. The estimated 44.35 LT and 37.75 LT respective handling weights for the ACB Lighter center and raked modules are within the stated capabilities of the high capacity handling equipment.

Therefore, commercial container terminals and military cargo terminals equipped with this high capacity handling gear could handle (load/offload) the ACB Lighter modules. However, it can reasonably be assumed that the stockpiling and portside handling of the ACB Lighter modules will not take place in commercial container terminals but rather in designated cargo terminals of the Military Sealift Command (MSC).

6.2 Recommendations

MR&S recommends that in order to eliminate or reduce the present excess handling weight of the lighter modules and to possibly lower potential construction and maintenance costs the following issues be considered by NFESC for implementation in the future phases of the ACB Lighter program.

- Retain the best features such as the prealignment pin and bridle system of the present rigid connector design.

- Consider alternate solutions to the present bulky, heavy and difficult to integrate modular connector assembly. The present modular design is structurally intrusive and greatly increases the structural weight of the lighter modules.

- Consider increasing the module depth to 8'-6", the additional 6 inches of hull depth would allow to place the connector pins further apart in the vertical direction. The present 4'-0" centerline to centerline distance results in very high concentrated connector loads. In addition, locating the connector pins closer to the top and bottom sides of the module should also be considered for increased center distance. However, it should be noted that while the increased module depth and connection pin centerline distance would result in decrease in the connector loads for the same bending moment but would increase construction cost and cube required for transportation.

- While the presently selected raised cargo tie-down fittings are the lightest and least expensive to install the potential negative safety aspect of the raised installation for personnel on deck and for vehicle traffic and cargo (container) spotting should be reviewed for acceptability.

- Consider a new survey of the candidate container ships, commercial and Military Sealift Ships, to identify suitable cargo holds for the transportation of the 8 ft deep by 24 ft wide by 40 ft long ACB Lighter modules. Hold locations, container guide configurations, stack heights and current container support capacities should be identified and recorded. This information would facilitate future planning and ship utilization in case of need. Past surveys of similar scope have been performed for the SEA SHED project but the results are obsolete, many ships in the previous survey are no longer in service.